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#185 OCTOBER 2020

Sky at Night

THE UK'S BEST SELLING ASTRONOMY MAGAZINE

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MARS AT ITS BEST

Make the most of Mars's amazing opposition with our week by week observing guide

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Discover the hidden highlights of the dark-sky season

CRUMBLING COMETS

Why some are a spectacle while others break up and fade

SEE THE WINNERS

Insight Investment Astronomy Photographer of the Year

CASSIOPEIA'S GIANT

Find the star that's 450 times the size of the Sun

BIG DISH'S BIG DATE

Tim O'Brien on Jodrell Bank's 75th anniversary

SUPERNOVA SURPLUS

The galaxies brimming with stellar explosions

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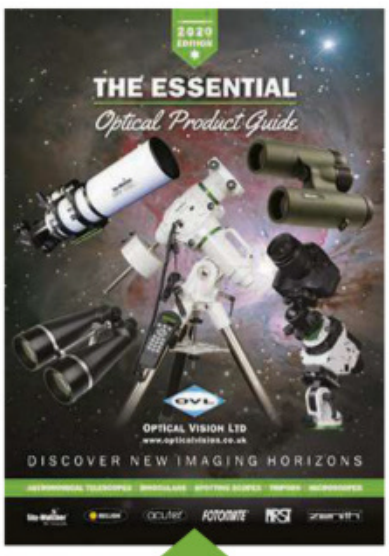

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Welcome

Enjoy the best opportunity to view Mars for years to come

At long last, one of the best oppositions of Mars in recent times is upon us. The Red Planet, on which so much scientific interest is focused (see **pages 16 and 98**), is riding high in October's sky and is at its brightest and best for observation. On **page 36**, you'll find Pete Lawrence's week-by-week guide to the surface features that are best presented through a telescope, so you can make the most of this opportunity; Mars won't be this bright or well placed again until 2033.

This month and for many to come, the planet will be a striking sight to the naked eye too, and you'll find locator charts, both wide- and narrow-field, in 'The Sky Guide' on **page 43** to help you pinpoint the salmon-pink object as it moves through the constellation of Pisces during the month.

Looking beyond Mars out into deep space, at his time of year the night sky also brings into view several prominent neighbouring galaxies of the Milky Way – all members of the Local Group. On **page 60** Paul Money shows you how to best see these far off 'island universes', whether you're observing with eyes alone, with a telescope or imaging. Their light has travelled millions of years to reach us, so don't blink!

One prominent member of the Local Group also features elsewhere in the magazine, as we're proud to bring you the winning images from 2020's Insight Investment Astronomy Photographer of the Year competition. There are some stunning images on **page 28** across the eight categories, two special prizes and Young competition, showing that neither the pandemic nor the lockdown have dented the entrants' imaging skills or the judges ability to select a winning set of groundbreaking images.

Enjoy the issue!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 22 October.

HOW TO CONTACT US

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16-PAGE CENTRE PULLOUT

The Sky Guide

COVER MAIN IMAGE: SCIEPRO/SCIENCE PHOTO LIBRARY/ISTOCK/GETTY IMAGES. THIS PAGE: NASA/USGS, PETER WARD, @THESHED_PHOTOSTUDIO, TOMMY NAWRATIL/CCDGUIDE.COM, MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO, NICOLAI BRÜGGER, BBC

New to astronomy?

To get started, check out our guides and glossary at
www.skyatnightmagazine.com/astronomy-for-beginners

This month's contributors

Lewis Dartnell

Astrobiologist

"I found it fascinating to research this month's 'Cutting Edge' – a topic that bridges Mars's past climate and landing a human mission there!"
Lewis finds out about the winds of Mars, page 16

Paul Money

Reviews editor

"I enjoy seeing M31 climbing higher into view in autumn – it's always a pleasure to explore our galactic neighbourhood from the back garden".
Paul guides us around the Local Group of galaxies, page 60

Dani Robertson

Dark sky officer

"The dark skies of Wales are a precious resource, so I'm proud to be involved in a campaign to protect the quality of our night skies for generations to come." **Dani highlights the threat of light pollution,** page 25

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/3XAE3DB/** to access this month's selection of exclusive Bonus Content

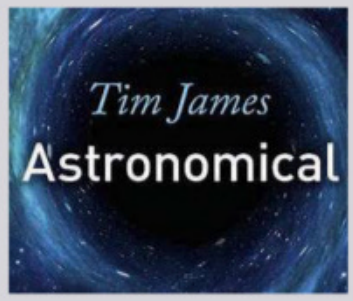
OCTOBER HIGHLIGHTS

Interview: stratosphere observatory

NASA's Jose Siles on the 2.5m telescope attached to a helium balloon that will study galactic star formation.

Watch August's *The Sky at Night*

The team look back over 50 years of the BBC's Mars coverage and explore our fascination with the Red Planet.



Audiobook preview: *Astronomical*

Listen to two chapters from a new audiobook revealing some of most the incredible discoveries made in astronomy.

The Virtual Planetarium

Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

COMET NEOWISE SPECIAL

EYE ON THE SKY

WHEN NEOWISE DROPPED BY

A look back at the spectacular comet that graced our skies in July

"As soon as we saw how close it would come to the Sun, we had hopes that it would put on a good show," said Amy Mainzer, NEOWISE principal investigator at the University of Arizona.

And indeed it did.

First spotted by NASA's Near-Earth Object Wide-field Infrared Survey Explorer (NEOWISE) mission on 27 March, the icy visitor Comet C/2020 F3 NEOWISE survived the roasting of its close journey past our Sun to put on a stunning show.

Through much of July we were wowed by nightly views of it streaking across from Capella to below the Plough, its twin tails stretching for millions of kilometres behind it. Glowing as bright as mag. –2 at its peak, it was seen easily with the naked eye, but was an unalloyed joy when seen with binoculars and small telescopes. By late in the month its green smudgy coma was still evident, but all too soon it faded from view as it headed back to the cold outer reaches of the Solar System.

To rekindle those thrilling days, we've compiled some of the most remarkable images of the comet, from the ground and from space.

Sailing over Beccles ▷

JASON DURRANT, SUFFOLK, 11 JULY 2020

On 11 July at 12:30am I went to a local spot – by the River Waveney, near Beccles in Suffolk – with a fellow astrophotographer friend of mine. The comet was low, but it was bright enough for its reflection in the still river water to be visible with the naked eye. The comet was captured on my Sony A7III digital camera with a Tamron 28-70mm f/2.8 lens, using 5-second exposures at f/2.8 and an ISO of 3200. Six images were then stacked and processed in Adobe Lightroom and Photoshop to create the final picture.

JASON DURRANT

COMET NEOWISE SPECIAL

MORE ONLINE

See more stunning pictures of Comet NEOWISE

NASA/JPL-CALTECH, SALEM SHAMMAKH, LEE HARRIS, D.PEACH/I.SHARP, NASA/JOHNS HOPKINS APL/NAVAL RESEARCH LAB/PARKER SOLAR PROBE/GUILLERMO STENBORG

△ First sighting

NASA'S NEAR-EARTH OBJECT WIDE-FIELD INFRARED SURVEY EXPLORER, 27 MARCH 2020

Comet NEOWISE appears as a string of fuzzy red dots in this composite of several heat-sensitive infrared images taken by NASA's NEOWISE (Near-Earth Object Wide-field Infrared Survey Explorer) mission on 27 March. Classified as a comet on 31 March, it was named after NEOWISE on 1 April and excitement began to build that it might reach naked-eye brightness.

◁ Breezing by Bath

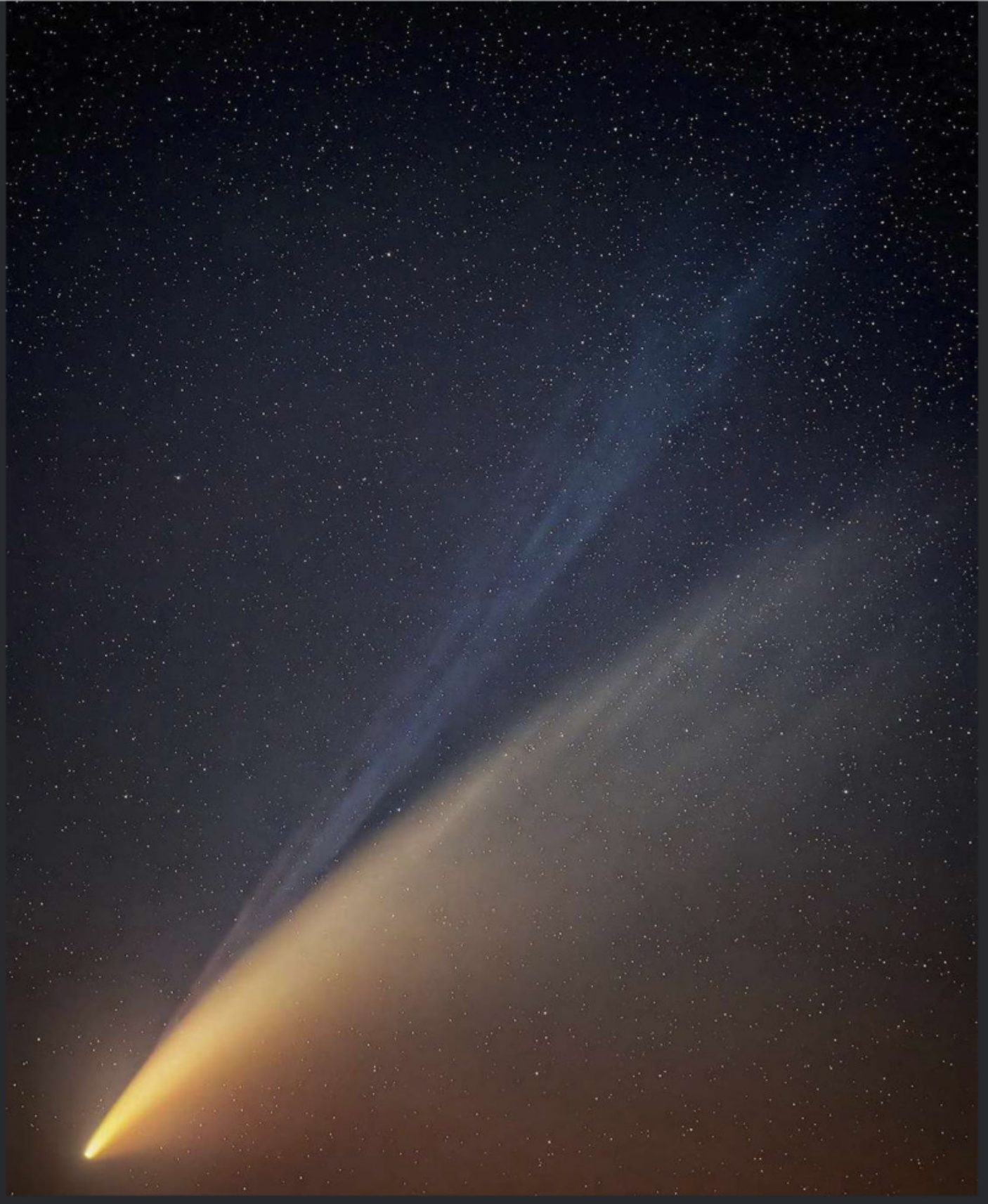
SALEM SHAMMAKH, BATH, 11 JULY 2020

NEOWISE cruises over the historic city of Bath in the early hours of 11 July.

Burning bright ▷

LEE HARRIS, SEVERN ESTUARY, NEAR BRISTOL, 10–11 JULY 2020

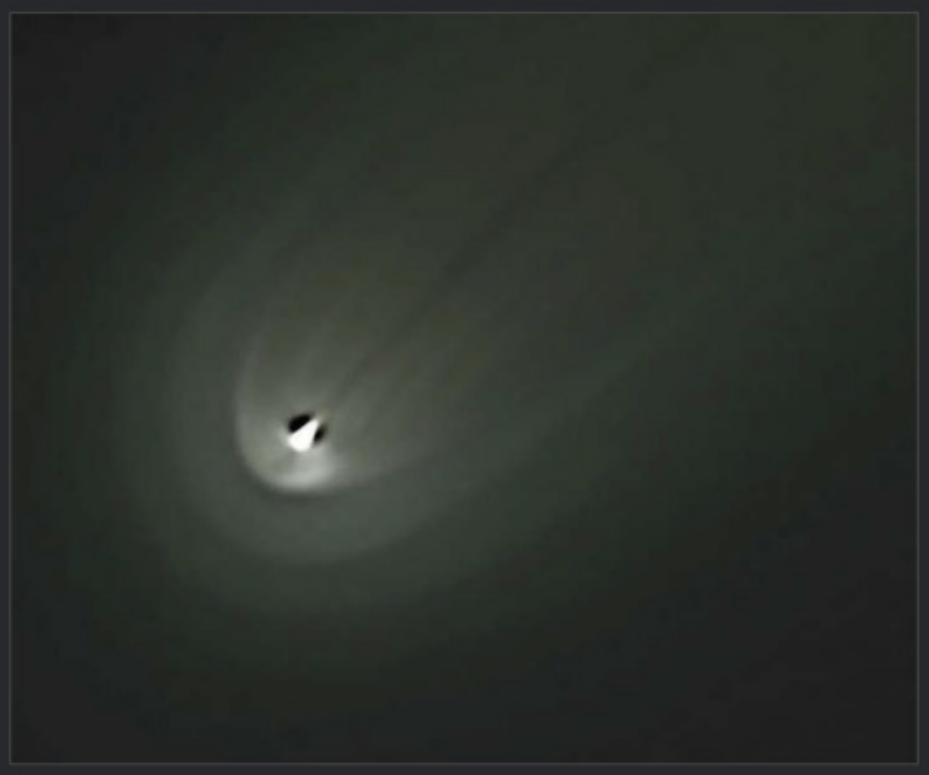
"One of the highlights of my life" is how Lee describes capturing this astonishing picture, which clearly shows the comet's dust and ion tails.



▽ Nucleus close up

DAMIAN PEACH, SELSEY, 17 JULY 2020

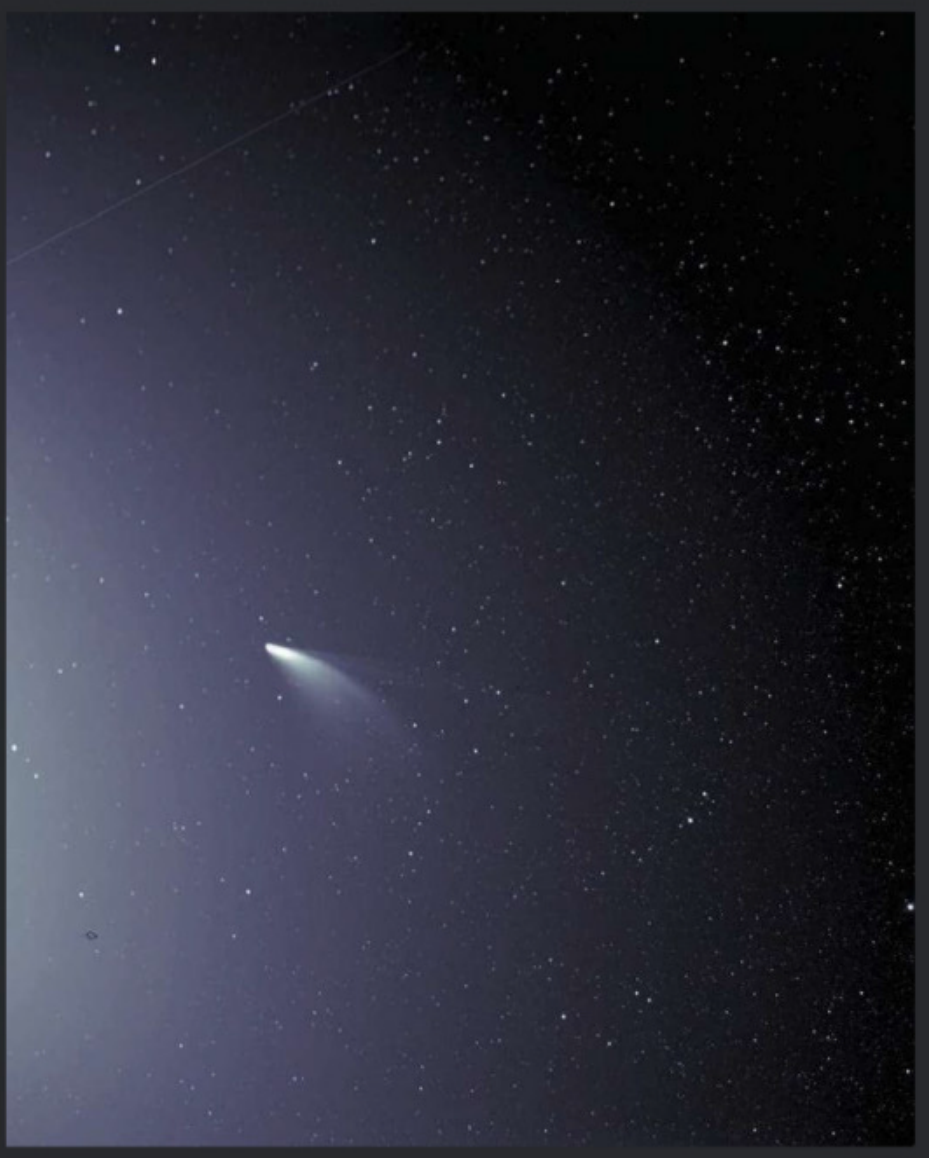
Professional astrophotographer Damian's high-resolution close-up shows the comet's inner coma and the dust 'shells' being generated from the jets on the rotating nucleus.



Right place, right time ▷

PARKER SOLAR PROBE, 5 JULY 2020

NASA's probe happened to be in just the right position to capture the comet after its closest approach to the Sun, revealing its broad, fuzzy lower dust tail and narrower upper ion tail. The image also helped confirm the diameter of the comet nucleus as approximately 5km.



Thank you, Sylvia

Sylvia left a gift in her Will to help conquer Stroke

The first we knew of Sylvia was when we received notification of the gift she'd left us in her Will. Shortly after, a beautiful story of a much-loved woman began to unfurl.

Friends remembered Sylvia's kind-heart and her wish to help others. She spent part of her adult-life caring for her mother, and developed a passion for medicine. Becoming a medical secretary was her next step and, in the course of her career, she discovered the devastating impact a stroke could have on people and their families. She saw that research and treatment were vastly under-funded, and she decided to remember the Stroke Association in her Will.

Sylvia's gift has helped fund our work to conquer stroke. She's supported research to prevent and treat stroke, and she's helped care for survivors. And that's something you can do too – in the same way.

If you would like to learn more about remembering the Stroke Association in your Will, please get in touch.

Call 020 75661505 email legacy@stroke.org.uk or visit stroke.org.uk/legacy

Stroke association

The latest astronomy and space news, written by Ezzy Pearson

BULLETIN

Betelgeuse's dimming explained

The star's exceptional dimness earlier this year was observed during a Hubble study

A stellar 'sneeze' was responsible for Betelgeuse's unprecedented period of dimming at the beginning of the year, according to a recent update from astronomers who had been monitoring the star. They revealed that it had experienced an outburst of a huge cloud of material just before it began to dim, hiding a quarter of the star from view.

Betelgeuse is a red giant and a favourite for astronomers, partly due to its prominence in the constellation of Orion and partly because it's expected to go supernova at any time in the next 100,000 years. Its brightness is known to vary slightly, but in October 2019 it dimmed dramatically and by mid-February it was around three times fainter than normal.

The star then recovered, and by April it was as bright as ever, leaving astronomers to wonder what had caused the massive reduction in brightness. Fortunately for those investigating, the star had been monitored for months running up to the episode by the Hubble Space Telescope. A three-year study into Betelgeuse's outer atmosphere has been regularly monitoring the star since early 2019, examining it in the ultraviolet wavelengths needed to see the hottest materials surrounding the star.

"With Hubble, we had previously observed hot convection cells on the surface of Betelgeuse and in the [autumn] of 2019 we discovered a large amount of dense hot gas moving outwards through Betelgeuse's extended atmosphere," says Andrea Dupree from the Harvard-Smithsonian Center for Astrophysics. "We think this gas cooled down millions of miles outside the star to form the dust that blocked the southern part of the star, which was imaged in January and February."
www.hubblesite.org

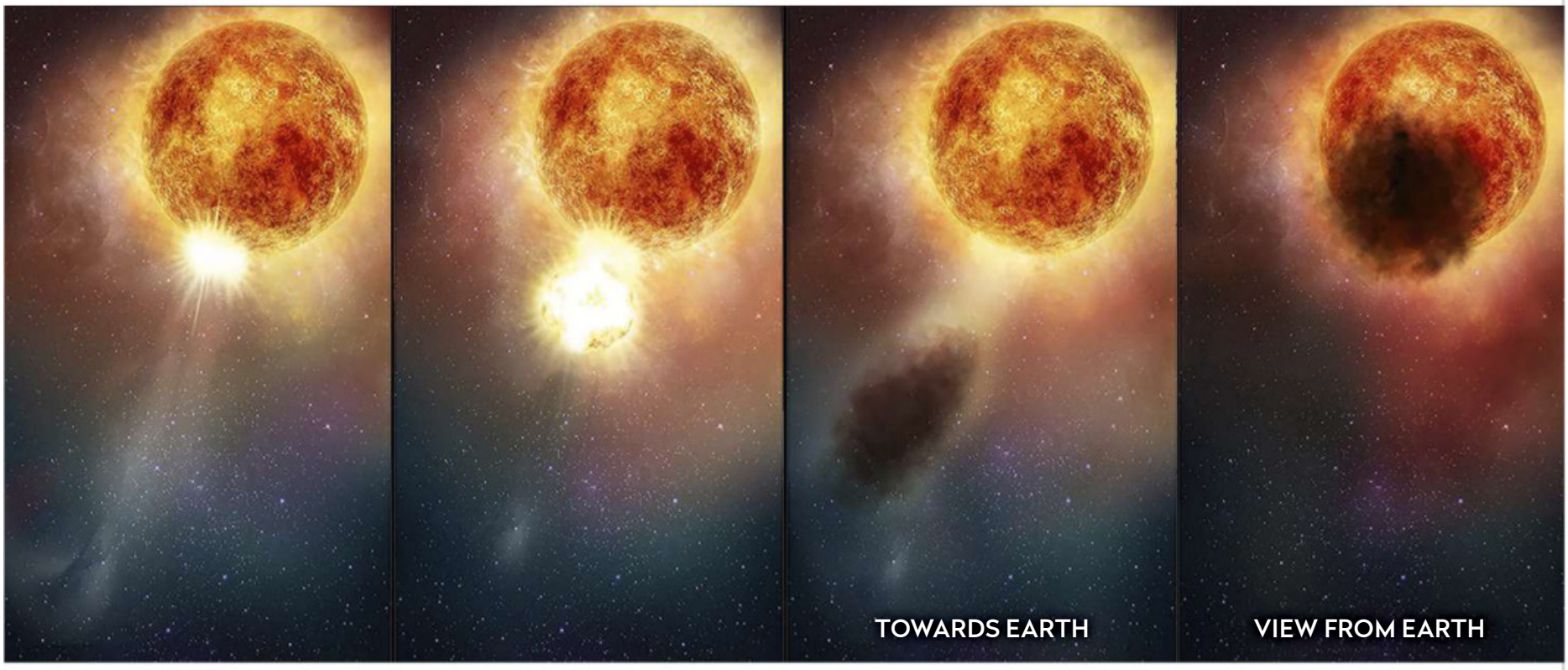


ILLUSTRATION NASA/ESA AND E. WHEATLEY (STSCI)

▲ **'Stellar sneeze': a huge outburst of gaseous material from Betelgeuse is believed to have been responsible for blocking out its light**

Comment

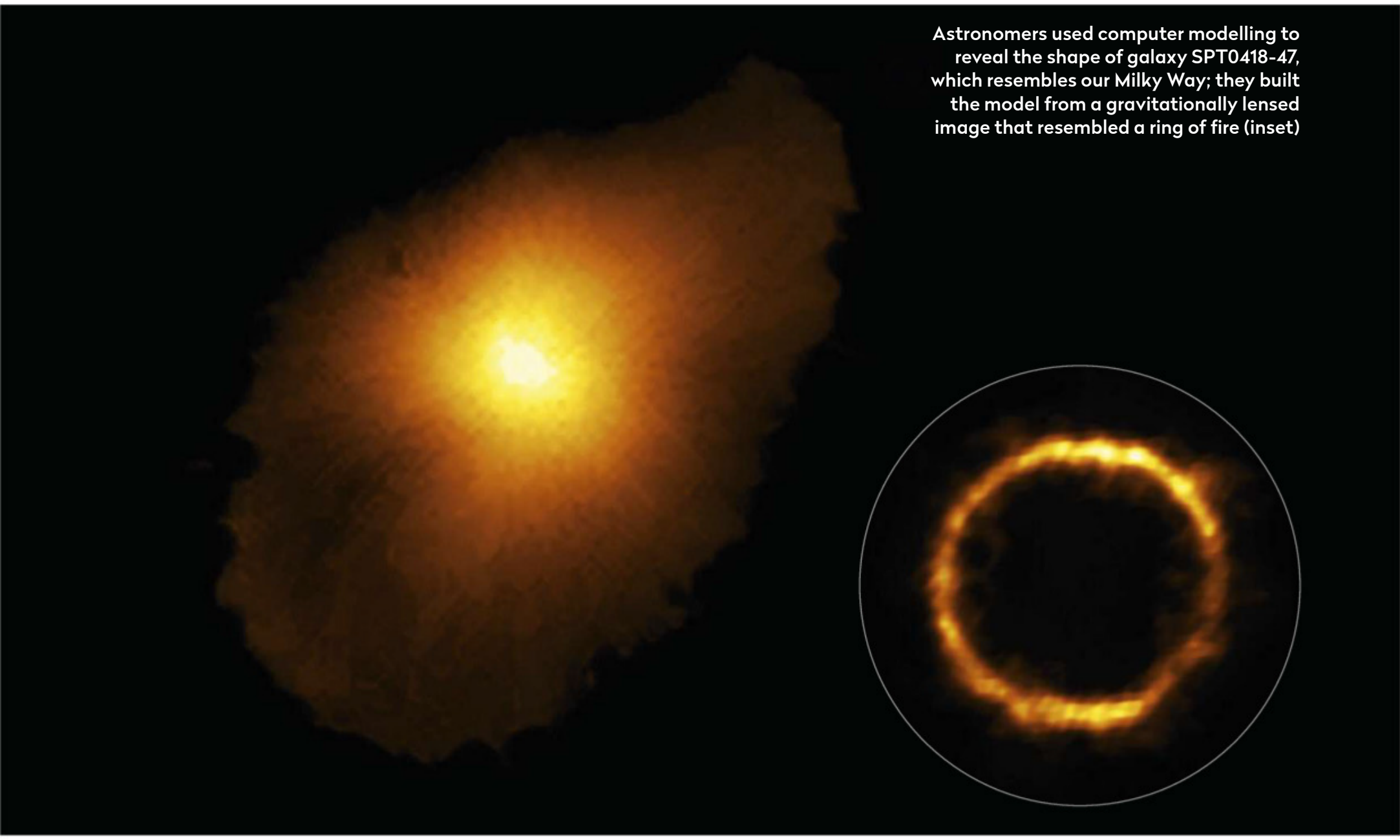
by Chris Lintott

Following its historic dip, you might think Betelgeuse had been quietly shining away. In reality, since May it has been fading once again.

So are we in for a repeat performance? Perhaps, but probably not; changing brightness is just one of the things that stars as large as Betelgeuse do. The red giant is enormous – placed at our Solar System's centre it would stretch nearly to Jupiter's orbit – and therefore it is remarkable for its low density.

Something so tenuous is bound to wobble every so often. Betelgeuse shows semi-regular patterns of varying brightness with periods ranging from three to 400 days, plus irregular changes on top. Though the events of the last year were exceptional, further changes should be expected from this most interesting of stars.

Chris Lintott co-presents *The Sky at Night*



Astronomers used computer modelling to reveal the shape of galaxy SPT0418-47, which resembles our Milky Way; they built the model from a gravitationally lensed image that resembled a ring of fire (inset)

ALMA (ESO/NAOJ/NRAO) RIZZO ET AL, NASA/JPL-CALTECH X 2, 3QUARKS/ISTOCK/GETTY IMAGES

Milky Way's distant lookalike discovered

The ordered galaxy challenges current ideas about how galaxies grow

Astronomers have spotted a galaxy which bears a striking resemblance to the Milky Way, but which is so far away we're seeing it as it was when the Universe was just 1.4 billion years old. This is the furthest away such a lookalike galaxy has ever been found.

The galaxy, named SPT0418-47, possesses a similar rotating disc and central bulge to our own Milky Way, though it lacks its spiral arms. The discovery of this structure so early on in the galaxy's growth came as a surprise to astronomers, as most theories predict young galaxies should be too turbulent to create such features.

"This result represents a breakthrough in the field of galaxy formation, showing that the structures we observe in nearby spiral galaxies and in our Milky Way were already in place 12 billion years ago," says Francesca Rizzo from the Max Planck Institute for Astrophysics in Germany, who led the study.

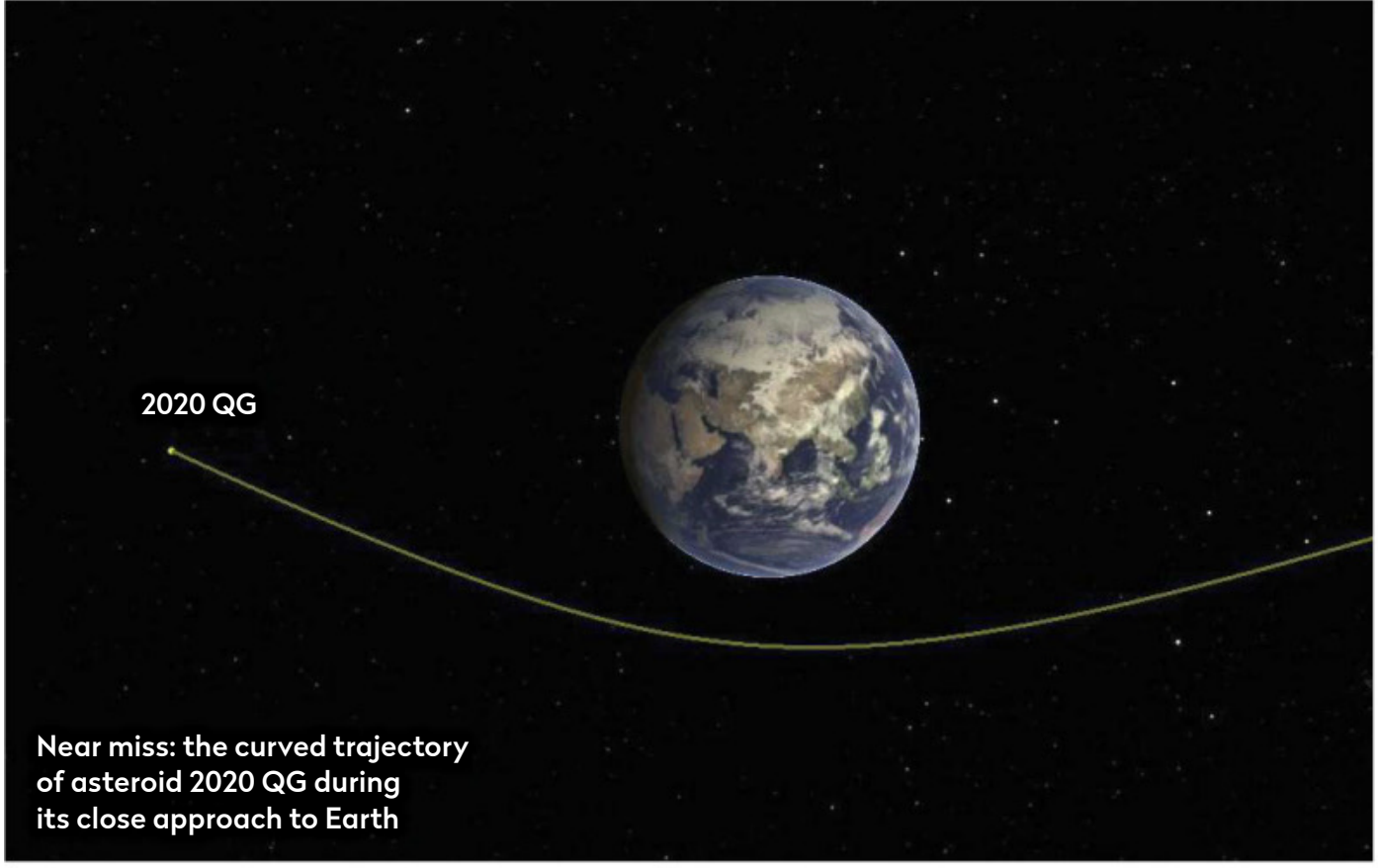
The find will allow astronomers to study a galaxy during these critical early years of its growth. Normally galaxies from this era are so distant and dim it's impossible to see any detail. However, this particular galaxy's light had been greatly magnified due to gravitational lensing, where a nearer galaxy's gravity bends the light of a more distant object. This process boosts its brightness significantly but distorts the image in the process.

Astronomers can undo this distortion, however, using computer modelling to reconstruct what the distant galaxy actually looks like. When Rizzo's team did so, they revealed a remarkably structured and ordered young galaxy.

"What we found was quite puzzling; despite forming stars at a high rate, and therefore being the site of highly energetic processes, SPT0418-47 is the most well-ordered galaxy disc ever observed in the early Universe," says Simona Vegetti, also from the Max Planck Institute for Astrophysics, who took part in the research. "This result is quite unexpected and has important implications for how we think galaxies evolve."

The evolution of this specific galaxy, however, already looks set. Despite its resemblance to our own spiral galaxy in its youth, this distant look-alike will probably grow to become a giant elliptical galaxy.

www.mpa-garching.mpg.de



ILLUSTRATION

Near miss: the curved trajectory of asteroid 2020 QG during its close approach to Earth

Mini asteroid makes closest flyby on record

The interaction deflected the asteroid's path by 45°

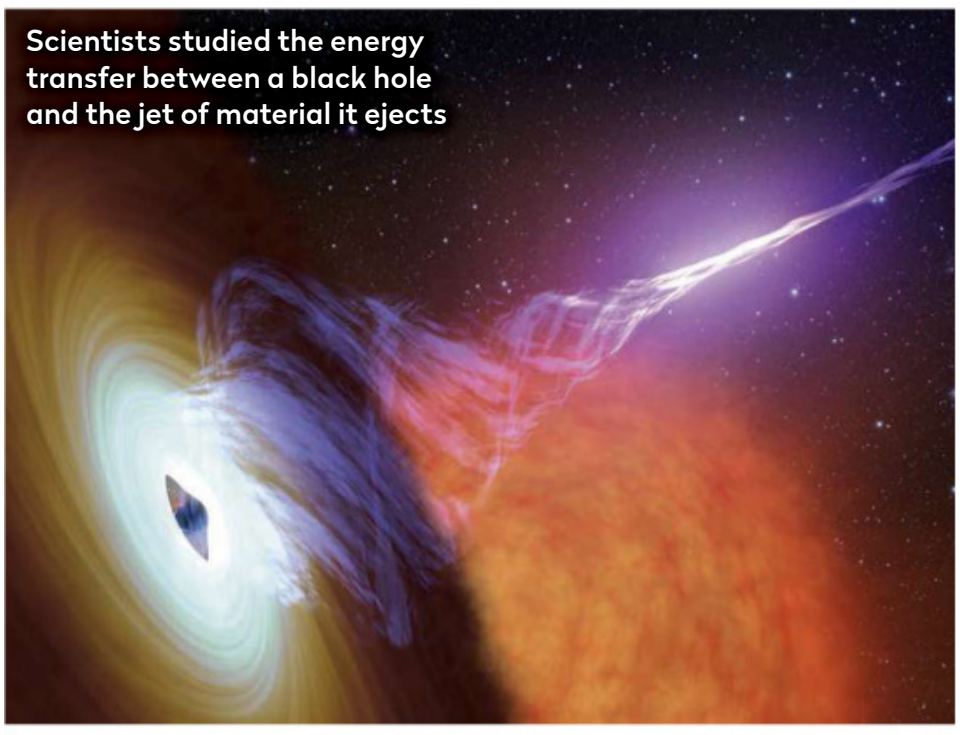
A van-sized asteroid buzzed past Earth on 16 August at a distance of just 2,950km – closer than any asteroid on record has come to the planet without crashing.

"It's really cool to see a small asteroid come by this close, because we can see the Earth's gravity dramatically bend its trajectory," says Paul Chodas, director of NASA's Center for Near-Earth Object Studies (CNEOS). "Our calculations show that this asteroid got turned by 45° or so as it swung by our planet."

While such a close call with an asteroid might seem concerning there was no danger as the space rock, named 2020 QG, was only around 3–6m in diameter. Asteroids this size hit Earth several times a year and break apart in the atmosphere, creating spectacular fireballs in the process.

https://cneos.jpl.nasa.gov/

Black hole powers jet with magnetism



ILLUSTRATION

Scientists studied the energy transfer between a black hole and the jet of material it ejects

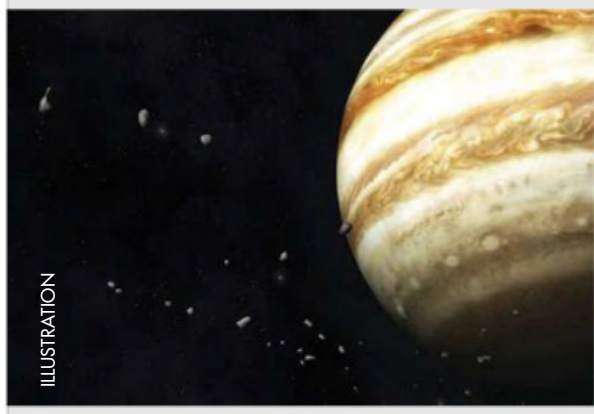
A black hole uses its own magnetism to invisibly beam energy out to one of its massive jets, in a novel process a new study has revealed.

Like many other giant black holes, distant quasar 3C279 is spitting out massive jets of material thousands of lightyears into space. However, when astronomers took a closer look at the object using the Event Horizon Telescope – a network of observatories which famously imaged the shadow of a black hole for the first time in 2017 – they saw the jet started a great distance away from the black hole with no apparent method of transferring energy between jet and black hole.

To take a deeper look at the unseen interaction between black hole and jet, astronomer Amit Shukla from the Indian Institute of Technology in Indore examined 3C279 at sub-millimetre wavelengths. This revealed that the light from the jet was flickering in a distinctive pattern which happens when magnetic field lines reconnect. This suggested the energy was carried away from the black hole along the magnetic field lines, before being deposited into the jet when they snapped together.

https://eventhorizontelescope.org/

NEWS IN BRIEF



ILLUSTRATION

Asteroids jumped Jupiter

A meteorite investigation reveals that asteroids in the early Solar System may have jumped the planetary gap created by Jupiter. Previously, scientists believed Jupiter cleared out an impassable gap in the disc of dust which formed the planets, but they have now found meteorites dating from this time which contain a mix of material from inner and outer regions.

Sun wasn't born alone

A new theory suggests the Sun may once have been part of a binary pair. The model could help explain the layout of icy objects in our outer Solar System, as a stellar companion would make our Sun more likely to steal outlying space rocks from other stars. The partner star would then itself have been stolen away by the pull of other nearby stars.

Lasers on the Moon

Astronomers have bounced a laser off the Lunar Reconnaissance Orbiter for the first time. Similar experiments were left on the Moon in the 1970s to measure the distance from Earth, but are now only 10 per cent as reflective as expected. The LRO data will help investigate the cause of the dullness.

NEWS IN BRIEF

SPACEX, UNIVERSITY OF CENTRAL FLORIDA, CAL-TECH CTX MOSAIC AND MAXAR/ESRI

Crew Dragon goes into operation

NASA has announced it will send its first official crew (above) to the ISS using Space X's Crew Dragon in late October. The announcement came shortly after SpaceX successfully completed its first crewed test of the vehicle. The mission will carry one Japanese and three American astronauts, who will form part of the Expedition 64 crew on the ISS.

Milky Way expels gas cloud

Astronomers recently discovered a cloud of cold gas which has been shot out of the centre of the Milky Way like a bullet. Similar clouds have been seen in other galaxies before, but never in our own. As the clouds that are expelled from our Galaxy remove material that could go on to form stars, the Milky Way could end up starving itself with such ejections.

Light pollution consultation

The UK's Houses of Parliament is conducting a public consultation to identify the main challenges to preserving dark skies and effective ways to overcome them. The consultation runs until 27 September. Visit **bit.ly/32JD7aD** for details.

BULLETIN

30m tear in Arecibo telescope's dish

A snapped cable is to blame for the extensive damage

Dramatic damage to Arecibo's main collecting disc

After surviving earthquakes and hurricanes, the Arecibo telescope in Puerto Rico has been forced to cease operations after a support cable snapped, ripping a 30m gash in the radio telescope's dish.

At 300m wide, Arecibo has been one of the largest and most powerful telescopes in the world for over 50 years, and astronomers are keen to see it back up and running. What caused the cable to snap isn't clear, but could be related to damage caused during Hurricane Maria in 2017, which the Arecibo team are still in the process of repairing.

"Our focus is assuring the safety of our staff, protecting the facilities and equipment, and restoring the facility to full operations as soon as possible so it can continue to assist scientists around the world," says Francisco Cordova, the Observatory's director.

www.naic.edu

Early Mars was iced over

▲ **Evidence of ice sheets: scientists have found similarities in the shapes of channels created on Mars (top) and those formed by glacier meltwater in Earth's Arctic region (bottom)**

A fresh look at Martian valleys has found they may have been created by melting glaciers, not free flowing rivers as previously thought.

For years, scientists assumed that several Martian channels and valleys were created by flowing rivers, and that early Mars was much warmer and wetter than it is today. But when planetary geologist Anna Grau Galofre from Arizona State University studied the features, she saw a striking resemblance to formations found in the Arctic created by water draining away from the underside of a glacier.

After comparing 10,000 images of Martian valleys to terrestrial counterparts, Grau Galofre's team found that only a fraction look like they were caused by free-flowing surface rivers, suggesting ancient Mars was not warm and wet, but covered in a great ice sheet.

"We tried to put everything together and bring up a hypothesis that hadn't really been considered: that channel and valley networks can form under ice sheets, as part of the drainage system that forms naturally under the ice sheet when there's water accumulated at the base," says Grau Galofre.

https://asunow.asu.edu

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Our experts examine the hottest new research

CUTTING EDGE

In *The Martian* the Red Planet's winds are fierce, but in reality we know little about their effects

The winds of Mars

To continue exploring the surface of Mars we must first understand its atmosphere

The film *The Martian* saw astronaut Mark Watney marooned on Mars after a dust-storm threatened to topple his crew's ascent craft. Although the film (and the book it's based on by Andy Weir) is pretty true to the science and technology that will be needed for a human mission to Mars, this opening scene played with dramatic licence. Even though Martian winds can peak at over 100kph, the atmosphere is so thin you would barely notice this buffeting a space suit.

That's not to say that a more complete understanding of Martian winds is not needed. Scott Guzewich of NASA's Goddard Space Flight Center has led the publication of a White Paper – a scientifically supported persuasive report – stressing the key importance of global Martian wind observations within the next decade.

A detailed description of the winds around Mars is a major missing piece of the jigsaw puzzle of our understanding of the planet's climate and the shaping of its features. Wind transports dust, water vapour, and trace gases like methane around the planet, and redistributes the Sun's warmth from the equator towards the poles. Over the past three billion years, winds have also been one of the most important processes for moulding the Martian landscape: depositing dust and burying older surfaces, moving dunes and eroding exposed rock formations. Grit-laden winds act like a persistent sand blaster and in some locations, material spanning depths of hundreds of metres has been eroded away. Soft, friable (crumbly), sedimentary layers are much more vulnerable than volcanic rocks, and it's these sedimentary accumulations that hold the secret to Mars's early climate; the story of ancient water and possible signs of preserved past life.

Risk assessments

Getting a clearer picture of the atmospheric behaviour on Mars is also important for safely sending human missions to the planet's surface. The entry, descent and landing sequence is affected by atmospheric variables – in particular the winds while descending under parachute – as is the launch from the surface back again. Equipment can be damaged by wind-blown dust; the Apollo missions to the Moon showed just how destructive fine, abrasive dust particles can be to the joints of a spacesuit. Solar panels providing power to the habitat are especially sensitive to the build-up of wind-blown sediment. A robust understanding of the winds blowing – not only at ground level but also at varying altitudes in the atmosphere – and how this atmospheric circulation changes with the seasons, is crucial for reducing the uncertainty and the risks involved in crewed missions.

> ***"Getting a clearer picture of the atmospheric behaviour on Mars is important for sending human missions to the planet's surface"***

To plug these gaps in our knowledge, Guzewich and his colleagues argue that a comprehensive mapping of Martian winds must become a priority over the decade from 2023–32. They say that the necessary measurements are Martian wind direction and speed, from the surface up to at least 80km altitude, covering at least one Mars year and across the entire planet with a resolution of less than 300km. Suitable instruments are already in development to be ready to fly on Mars orbiter probes in the next decade. These include techniques like Lidar (that functions like radar but with a laser beam), which can measure wind speeds by looking at the suspended dust in the lower 50km of the atmosphere. This works day or night, and even within dust storms, which we are most in the dark about at the moment.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Lewis Dartnell was reading... *Measuring Mars Atmospheric Winds from Orbit: A White Paper submitted to the Planetary Science and Astrobiology Decadal Survey 2023-2032* by Scott Guzewich et al. **Read it online at https://arxiv.org/abs/2007.05412**

Exploding galaxies

While the Milky Way hasn't had a supernova in 400 years, other galaxies are bursting with them

Astronomers all over the world dream of a bright supernova. We haven't caught such an event in our own Galaxy since before the telescope was invented, and a typical system like the Milky Way might expect no more than one a century. Some galaxies seem blessed; M61, for example, a rare spiral galaxy in the Virgo Cluster, has had eight since 1900.

Why some galaxies should have more supernovae is something of a puzzle. Most supernovae represent the death of massive stars, and so galaxies with more supernovae are likely to have more massive stars. As such behemoths burn through their fuel quickly, living for only a few hundred million years or so, their presence indicates recent star formation. Supernovae are therefore signs that a galaxy is alive and happily making stars.

Galaxies that have more supernovae do have higher rates of star formation but otherwise appear completely normal, with little to distinguish them from their neighbours. This month's paper takes a close look at NGC 2770, a spiral galaxy that appears to buck this trend. Three definite supernovae have been found in the galaxy in the last 20 years – in 1999, 2007 and 2008 – and a fourth candidate, in 2015, is either a supernova or an outburst from a type of giant star called a luminous blue variable. Despite these fireworks, NGC 2270 seems to have a normal, rather than an enhanced, star formation rate. What's going on?

Prof Chris Lintott is an astrophysicist and co-presenter on *The Sky at Night*

"NGC 2770's high star-formation rate may be because it has just survived an interaction with a neighbouring galaxy"

Counting stars

Previous attempts to work out how many stars NGC 2770 is forming depended on observations made with a radio telescope in Westerbork, the Netherlands. Hydrogen is the fuel for star formation and so finding a galaxy rich in the gas usually means a more productive stellar nursery. Based on these observations, NGC 2770 seemed to have a star formation rate of about one solar mass per year – more or less the same as our own Milky Way. To explain the observed burst of supernovae, a rate of 20 times that would be necessary.

So, how do we explain this difference? In this month's paper, a team led by Michal Michalowski of the Adam Mickiewicz University in Poland lay the blame on dust, so often a confounding factor in observations. Dust – particles of silicon and carbon – absorbs light, making the galaxy appear fainter in the wavelengths that reveal star formation than would otherwise be the case. Dust is associated with star formation, so it's not unexpected for the two to go together, but the size of the correction is surprising. Once dust is properly measured and accounted for, the star formation rate for the galaxy is nearly 50 solar masses per year – more than enough to explain the supernovae.

But why does NGC 2770 have such a high star formation rate? One possibility is that it may have just survived an interaction with a neighbouring galaxy; there's a faint bridge of matter linking the main galaxy to one of its companions, a typical sign of an ongoing merger. Such interactions often stir up gas, triggering star formation. It's possible that our own Milky Way might undergo a similar burst of star formation in a few billion years when it interacts with Andromeda. Impatient astronomers may not want to wait that long, though, and will be keeping their fingers crossed in the meantime.

Three images of NGC 2770 from early 2008 show the rare occurrence of two supernovae

Chris Lintott was reading... *NGC 2770: high supernova rate due to interaction* by Michał J. Michałowski et al.
Read it online at: https://arxiv.org/abs/2008.08091

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

As *The Sky at Night* marks the 75th anniversary of Jodrell Bank Observatory, its Associate Director **Tim O'Brien** looks at how radio astronomy has changed our view of the Universe

One of the more frustrating things about being an astronomer is that we can't go and have a close look at our favourite objects. Instead, we have to gather as much information as we can while we're stuck here on Earth. That means collecting radiation across the electromagnetic spectrum (as well as particles and gravitational waves where we can).

I think of it as resembling a jigsaw – where each bit of information we collect, whether it's visible light, radio waves or X-rays, is like a separate piece. Only when you put them all together do you get a complete picture.

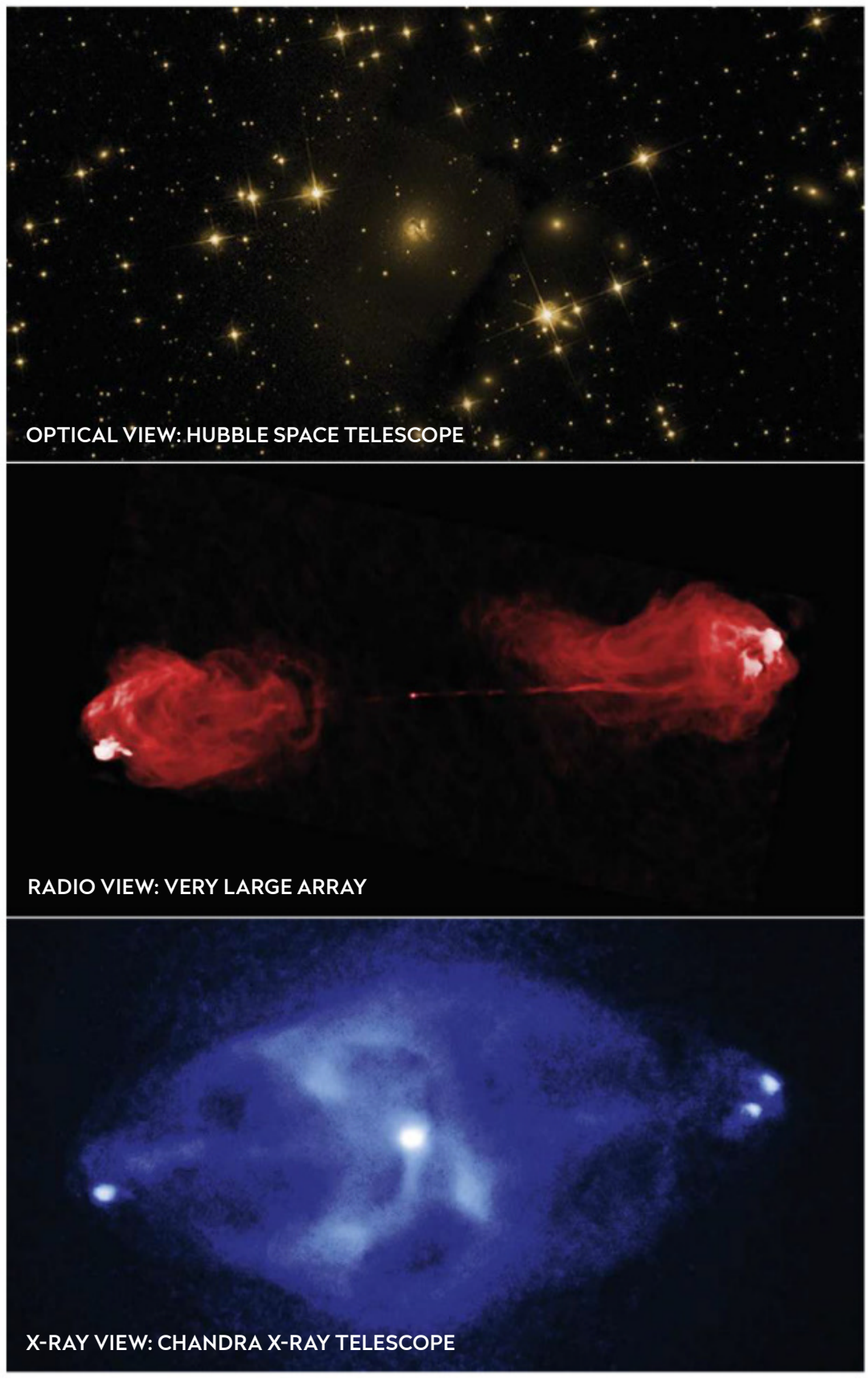
This year marks the 75th anniversary of the first observations at Jodrell Bank Observatory (originally called the Jodrell Bank Experimental Station). Bernard Lovell established the station after he returned from the Second World War as he was determined to use the radar technology (which he had helped develop for defence) to further his study of cosmic rays – high-speed charged particles arriving from outer space.

In his attempts to detect radar echoes from these cosmic rays – a task he never managed – Lovell built larger and larger radio aerials. These turned out to be perfect for studying radio emissions from the distant Universe. He had accidentally become one of the first radio astronomers.

Radio revolution

For thousands of years, people had looked at the sky with their eyes – first on their own, and then through telescopes. But when Lovell and others started to look at the Universe with radio eyes, they saw completely new things. Instead of the stars in the night sky, a radio telescope sees the stuff between the stars, the radio waves produced by electrons spiralling around the magnetic field of the Galaxy.

Scattered across the sky we see what look like stars, but these turn out to be bright points of radio light from the regions around supermassive black holes at the centres of other galaxies.



▲ The galaxy Cygnus A – at a distance of 750 million lightyears – viewed at three different wavelengths, all at the same scale, showing foreground stars and the central galaxy (top); radio jets and lobes extending about half a million lightyears (middle); and the hot gas enveloping the galaxy (bottom)

One of these 'radio stars', the galaxy Cygnus A (pictured above) is in the constellation of Cygnus, The Swan, and it's a good example of the power of multiwavelength observations. Despite it being one of the brightest objects in the radio sky, there was nothing obvious when the astronomers looked at that position with optical telescopes. Just a faint

OPTICAL: NASA/STSCI; RADIO: NSF/NRAO/AUI/VLA; X-RAY: NASA/CXC/SAO, NASA, FARM IMAGES/CONTRIBUTOR/ISTOCK/GETTY IMAGES

Tim O'Brien is a Professor of Astrophysics and is Associate Director of Jodrell Bank Observatory

fuzzy nebulosity was visible; at the time it was thought that this might be two galaxies colliding.

Unfortunately, the view with a single radio telescope is blurred and a source like Cygnus A just looks like a large featureless blob. In order to get a sharper view, radio astronomers began connecting together multiple telescopes separated by large distances – a technique known as interferometry. This method overcame this limitation, resulting in the sharpest views available to astronomy. (A recent example is the Event Horizon Telescope's image of the supermassive black hole in M87.) By using this approach in the 1950s, Roger Jennison and Mrinal Dasgupta showed that the visible nebulosity of Cygnus A was situated between two bright sources of radio emission.

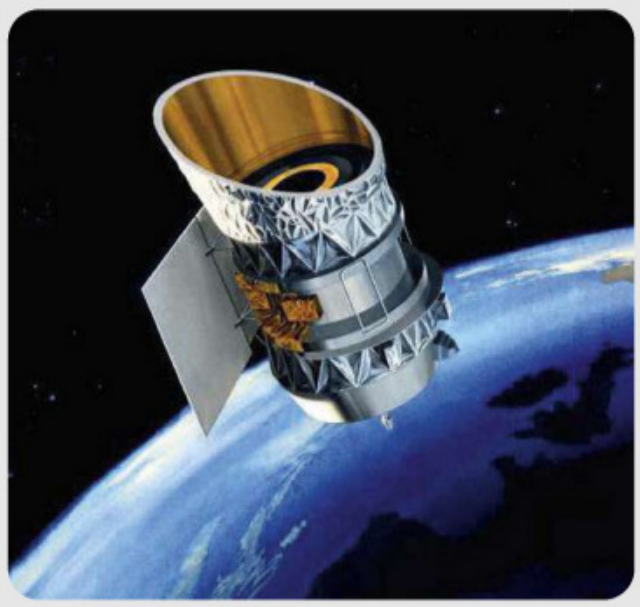
Modern views of Cygnus A, and other radio galaxies, show that the two radio lobes are produced by jets of material shooting from the centre of a galaxy in opposite directions. We can now look back and see that these remarkable objects remained undiscovered until we looked at the sky with radio eyes.

Whenever we look at the sky at a different wavelength, we discover something new, another piece in the cosmic jigsaw puzzle whose full picture is still emerging.

Looking back: The Sky at Night

1 October 1983

On 1 October 1983, *The Sky at Night* took a look at the work being done by NASA's Infrared Astronomical Satellite (IRAS). Since January of that year, the observatory had been surveying the entire night sky at infrared wavelengths. As the Earth's atmosphere soaks up most of these wavelengths, the space-based IRAS was the first time astronomers had been able to accomplish this task.



▲ **NASA's IRAS revealed over a quarter of a million infrared sources**

The mission ended in November 1983, when the spacecraft ran out of the helium it used to cool itself. By then it had surveyed the sky four times and revealed over a quarter of a million infrared sources. These ranged from asteroids and comets, to dusty discs around stars that would go on to form planets, all the way out to distant galaxies bursting with newly born stars.

With rules to mitigate space junk still decades away, NASA left the satellite in orbit. It was a decision it almost came to regret when, on 29 January 2020, IRAS nearly collided with a defunct military satellite: astronomers watched nervously as the two craft squeaked past each other, passing with as little as 13m between them. Fortunately, no new space debris was created by the meeting.

Beyond the Visible

This episode was originally scheduled for September but will now run in October

Astronomy is perceived to be a visual science, but should we really believe our eyes when we see beautiful images of celestial objects? The team visit Jodrell Bank Observatory to investigate how we explore the Universe using the light our eyes can't see. And what of our other senses? By using all our senses can we expand our capacity for new discoveries?

BBC Four, **11 October**, 10pm (first repeat BBC Four, date and time to be confirmed)
Check www.bbc.co.uk/skyatnight for more up-to-date information

▲ **The team visit Jodrell Bank in Cheshire to celebrate 75 years of radio astronomy**

Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

This month's top prize:
four Philip's titles

PHILIP'S

The 'Message of the Month' writer will receive a bundle of four top titles courtesy of astronomy publisher Philip's: Ian Ridpath and Wil Tirion's *Star Chart*, Robin Scagell's *Guide to the Northern Constellations*, Heather Couper and Nigel Henbest's *2021 Stargazing*, and a planisphere for the night skies as they appear at latitude 51.5° north.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

MESSAGE OF THE MONTH

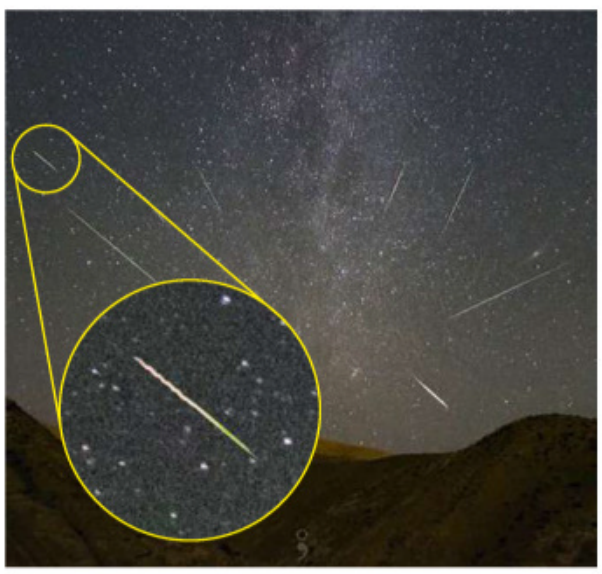
One night, two meteors

For most of my life I've been an armchair astronomer, occasionally venturing out and lying on the ground to marvel at the stars, meteors and satellites. I live in Cambridge with lots of light pollution so have never tried to image the night sky. Enter the August issue of *BBC Sky at Night Magazine*! I read the articles by Stuart Atkinson: "Just be content to stand there in the dark and wait for shooting stars..."; and by Pete Lawrence: "Can you capture a Perseid?" and decided that since I have a GoPro, there must be a chance, even with street lights. Well, the night of 6 August was clear and I thought I would practise. Guided by hints and tips from the magazine's articles, I opted for an exposure of 30 seconds at ISO 400 and took a few hundred images of different parts of the sky. I managed to capture two meteors, the first passing through Ursa Major (not a Perseid) and the second streaking past Mirfak (certainly a Perseid); how lucky was that? They're not brilliant images (there is some trailing), but thanks to those articles and the challenge to try astrophotography, it's great that I can identify the whole of Perseus and Mirfak, the Pleiades, Ursa Major and Capella, in addition to capturing the meteors. Thanks for reawakening the night sky for me!

Meteor double: Phil's shots of two meteors, one passing the Plough (left) and another passing Perseus (right)

Phil Seeney, Cambridge

A pleasure, Phil. Here's hoping you continue to get inspiration as we move into dark sky season! ***– Ed.***



Different course

Here is my composite stacked image of the Perseid meteor shower, captured two years ago on its peak. I only edited it a few days ago and while I was doing so I noticed that one of the meteors didn't have a straight trail. I'd heard of these meteors before, but never seen one. I thought this might be a great example for showing how differences in meteor shape and aerodynamics – and in layers of air – can affect their path as they pass through the atmosphere.

Omid Qadrdan, Iran

Under the stars

Amateur astronomy is an interest which I've always kept alive with monthly doses of your magazine, but it had gradually been pushed aside as other things took over. However, a recent experience reinspired me. I was excited to find out my wife had booked a night away in a yurt in the country, and it was on the peak of the Perseid meteor shower. I was thrilled that it was in a dark-sky site, though the forecast for storms all night was disappointing. Sure enough, as darkness set in, rain started to fall. We retired to the yurt, but I later ventured out to see stars twinkling in half of the sky and an immediate shooting star, followed by a flash of lightning from a storm to the north. I lay on a bench, fascinated by the meteor shower display in one half of the sky and the lightning storm in the other. Sure, this prevented my eyes from fully adjusting, but it didn't stop me from seeing more shooting stars than I'd ever seen before, and the distinct smudge of the Milky Way. When I got home, I was still in awe of nature's display and felt inspired to clean and collimate my telescope, brush up on my astronomy and dust off my old issues of *BBC Sky at Night Magazine* to plan a checklist for the rest of 2020!

Andrew Holmes, via email

Tweets

Joanna
@Joeynoble • Aug 24
Anyone else missing the days we could watch comets and noctilucent clouds from our back gardens?! #astro #backgardenastro #cometNeowise #nightsky @skyatnightmag @AP_Magazine

Looking up

I took this photo of the lunar landscape (above) on 11 August using a simple method: with the lens of my digital camera held up close to the 20mm eyepiece of my Celestron AstroMaster 70 telescope. Using the lens's macro setting with the camera's steady-shot facility helped add to the result. I hope this will encourage other readers to see that it's possible to achieve fairly detailed shots using basic equipment. Thank you for keeping the magazine going over the COVID-19 outbreak: the magazine, and astronomy itself, remind me that we can put out of mind the problems of this small planet and escape to places where such things do not exist. As the 1930s film comedian Will Hay (a Fellow of the Royal Astronomical Society, no less) once said, those who hold an interest in astronomy, "see life in its true proportion".
Ed Hodson, Winchester ▸

ON FACEBOOK

WE ASKED: What are you most looking forward to about the return of longer nights?

Jason Hart
I look forward to the darker September evenings, as the Milky Way is at its best and there are great deep-sky objects, including the Dumbbell and Ring Nebulae.

Lynda McCaughey
Orion is my favourite constellation; I love the long, dark nights for stargazing.

Bob Kelly
It's more convenient to see the morning sky, as the time of sunrise heads later and later towards the shortest day of the year.

Kriss Starman
From the Andromeda Galaxy to the Pleiades, to the great conjunction of Saturn and Jupiter on 21 December.

Danny Castro
The clouds; they are the only thing visible in Scotland regardless of the time of year.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies
With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I use a Pentax K DSLR camera with an 18mm Sigma lens for astrophotography, but I'm surrounded by light pollution. Are there any filters you can recommend to combat this?
DAVID WEIGHTMAN


An IDAS LPS-D2 filter can combat the white light of modern LED streetlights

Older streetlights use sodium vapour that emit a distinctive orange glow, and you can buy filters which cut out this specific colour of light to combat the light pollution they create. The same goes for the blue-green of mercury lights. However, more modern LED streetlights emit white light across the spectrum. One filter that does have a positive impact on LED lighting is the IDAS LPS-D2, but this is only available in a limited number of sizes.

Your Pentax K DSLR and wide-angle Sigma 18mm lens combination would be best served by the use of 'clip in' style filters that fit inside the body of the camera, and although various types of light pollution filter are available in this format, none are suitable for LED light pollution.

The unfortunate truth is that if your local lighting is LED, you might be better off visiting a dark-sky location to avoid the pollution. If travel is not feasible then moving to narrowband imaging with a mono CCD camera would be a good option.

Steve's top tip

Why do I need a red light torch?

To ensure the best observations of celestial objects your eyes need to become 'dark adapted'. In darkness the photoreceptor 'rods' in your eye's retina change chemically to become more sensitive. This adaptation process can take up to 30 minutes, but it can be ruined in an instant by a bright light! However, your eye's rods are least sensitive to red light, so a relatively dim red light torch will allow you to read your star charts and see sufficiently to make adjustments to your equipment, without damaging your eyes' dark adaptation.

Steve Richards is a keen astro imager and an astronomy equipment expert

RICHJEM/ISTOCK/GETTY IMAGES

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Got it covered...

▸ I was interested to see the Pleiades face mask for sale in 'Gear' (August, page 88) as I've been wearing space-themed masks made by my wife since I started back at work after being on furlough. Many of my colleagues soon put in requests!
Paul Adamson, Somerset

Online inspiration

Last weekend, having just finished an online astronomy course, I was at a loose end. To amuse myself I started reading the August edition – and I'm no longer at a loose end! I've joined my local astronomy group's Facebook page, studied every article and despite a bad weather forecast, seen my first two meteors. The course, Astronomy: Exploring Time and Space, was in 'What's Online' (August) and I can recommend it. Don't expect to complete it in 44 hours though, the suggested reading is almost 2,000 pages, with videos, podcasts and slide decks. I'll be continuing my astronomy education aided by the magazine and I expect to make rapid progress.
George Sadler, via email

Instagram

Hannahbella_nel

The Chew Valley area really does have some spectacular skies. Saturn, Jupiter and the Milky Way visible as darkness falls. Bortle 4/5 is a treat when so close to two cities; there is a little light pollution as you can see. I love the night. I hope we get some clear ones again soon.
#chewvalley #nightphotography #milkywaychaser #longexposureoftheday #astrobritain #bbcskyatnightmag #darkskyshots

SOCIETY IN FOCUS

Hertford Astronomy Group (HAG) normally meets on the second Wednesday of each month from September to June. Our meetings are popular, often with over 75 people attending, but with the COVID-19 risk we decided to try a virtual meeting. Chairman Alan Willison sent out a message to our mailing list of over 700 subscribers, announcing that our May meeting would be online using Zoom. Here's how we got on...

Alan began the Zoom meeting and explained the format and introduced Martin Weston, who helps run HAG's active astrophotography section. He gave a run-down of sights to see in the night sky over the next month. He used Stellarium (just like he does at our physical meetings) and by sharing his screen everyone was able to watch as he took them around the night sky, pointing out sights of interest.

I then did a rundown on the state of America's activities in space exploration.

▲ Zoom time: Ian Willison, chairman of Hertford Astronomy Group

I had prepared a visual presentation of almost 150 images covering the Space Launch System (SLS) and Orion spacecraft, engine testing, preparations at Kennedy Space Center and programmes such as Starliner and X-37B, plus the work of SpaceX and Virgin Galactic. Viewers could post questions using Zoom's Chat facility.

Over 50 people took part in our first online meeting. It was a success and can be viewed on YouTube at **bit.ly/30rWBAs**.
Jerry Stone, HAG programme secretary
▸ www.hertsastro.org.uk

COVID-19

Events can begin to reopen from this month

Our pick of the best events from around the UK

WHAT'S ON

Kielder Forest Star Camp

Kielder Forest Park, Northumberland, 14–19 October

This autumn's informal meet-up is planned to go ahead, with reduced numbers and no indoor talks. For up-to-date info and bookings, check **kielderforeststarcamp.org**

Stargazing break

Dunster, Somerset, 23–25 October

Enjoy astronomy talks, Exmoor's dark skies and two nights' dinner, with bed and breakfast for £200 per person. Numbers are restricted and social distancing is in place. Contact **hotel@yarnmarkethotel.co.uk**. Check **bit.ly/exmoordarkskies** for other events in this year's slimmed-down Exmoor Dark Skies Festival (16–31 October).

Group stargazing

Libanus, Brecon, throughout October

An evening of stargazing for beginners, with an expert guide to show you around the night sky. Equipment is provided and COVID-19 restrictions mean that poor weather will force cancellation (instead of the usual indoor talk). Tickets are £20. **bit.ly/darkskywales**

DAVE WILLIAMS STARGAZING BREAK, NATIONAL MARITIME MUSEUM

PICK OF THE MONTH

▲ Space to explore: enjoy the world's finest astrophotography at the National Maritime Museum

Insight Investment Astronomy Photographer of the Year 2020

National Maritime Museum, Greenwich, starts 23 October

It's back: the world's premier astrophotography competition comes to London's National Maritime Museum once again, with a show that runs from 23 October through to summer 2021. As well as showcasing all of the winning images from this year's competition – out of a staggering 5,275 entries – there will be a crop of the most outstanding shortlisted photos. You'll see entries submitted from across the globe, in categories such as Skyscapes, Aurorae, People and Space, Stars and Nebulae, Our Moon and Planets, Comets and Asteroids.

There'll also be some spectacular photos in the categories of Young Astronomy Photographer, the Patrick Moore Prize for Best Newcomer, and the exciting Annie Maunder Prize for Image Innovation. Pre-book your tickets and a time slot online, as required by the museum's social distancing guidelines. Visit **www.rmg.co.uk/astrophoto**

WHAT'S ONLINE

Astronomical Society of Edinburgh

With regular talks and imaging advice webinars, the ASE hasn't let COVID-19 break its stride. Register for a free ticket on Eventbrite or catch their videos at: **bit.ly/AstronomicalSocEdinburgh**

Astronomy crosswords

While they remain closed, the Observatory Science Centre at Herstmonceux in East Sussex has created some astronomy-themed online fun, including cosmic objects to spot, crosswords, word searches and quizzes. **www.the-observatory.org/wordsearch**

Irish Astronomy Association

"Just because we're in lockdown, doesn't mean we can't look up" says Paul Evans, chair of the Irish Federation of Astronomical Societies, who's created informative online talks throughout lockdown. Find them here: **https://irishastro.org**

OUR 60MP CAMERA IS BACK!

Apx60

We're excited to announce that our 60 megapixel CMOS camera is back in development, and with a brand new name!

Welcome to the Apx60, formerly known as the CosMOS.
The Apx60 maintains the original vision for the camera, utilising the Sony IMX455 full frame CMOS sensor that is revolutionising amateur astronomy. This 60 megapixel sensor has low read noise, high quantum efficiency, and 16bit analogue to digital conversion.

Complete with high performance cooling, anti-condensation and anti-reflection optics, as well as in situ levelling for easy adjustment. The camera has a large memory buffer to prevent image artefacts and dropped frames. Additionally, the Apx60 is compatible with our intuitive live view Infinity software, and offers Atik's customary premium build quality.

The Apx60 is available to order NOW!
See our website for details of our worldwide dealers, or to order direct.

ATIK CAMERAS

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FIELD OF VIEW

Dark skies for the future

Can we save our night sky from the ever-growing threat of light pollution?

"Do you work for Darth Vader?" – that's usually the first question that comes out of people's mouths when I tell them I'm a Dark Sky Officer. Fortunately for me, I have a much better job than a Stormtrooper from *Star Wars*, working at the Dark Sky Reserve of Snowdonia National Park.

Humans evolved over centuries to respond to the natural cues of night and day. Then along came the electric light, and in just over 100 years we have rapidly altered our environment on a vast scale, leading to a phenomenon now well-known as light pollution. With his invention of the light bulb Thomas Edison believed he had liberated humans from the need for sleep, and has been quoted as saying, "Sleep is a criminal waste of time, inherited from our cave days." Today we know the importance of sleep to human health, and through its disruption of circadian rhythms there is evidence that light pollution is a cause of issues such as depression, insomnia, diabetes and even some forms of cancer.

Snowdonia National Park Authority has formed an 'allegiance of darkness' with the three protected landscapes in North Wales: the designated Areas of Outstanding Natural Beauty (AONBs) of Anglesey, Llŷn Peninsula, and the Clwydian Range and Dee Valley. Together we have created 'Prosiect Nos', a dark skies partnership dedicated to reducing light pollution and working to gain dark-sky protections for the AONBs via the International Dark-Sky Association (IDA).

Long-term satellite image data has shown that ALAN (Artificial Light At Night) is increasing 6 per cent year on year. It is widespread, affecting 88 per cent of Europe with only 2 per cent of people in the UK experiencing truly dark skies where they live. This means, unfortunately, that the majority of the population never get to stand under a starry night sky, gazing up in wonder. In this reality the Milky Way is invisible, meteor showers are a disappointing no-show and constellations are shrouded in an impenetrable, clinical white cloak of street lighting – with perhaps only the promise of a Starlink satellite to pique the interest of would-be stargazers.

The natural world too is paying the price for our addiction to light, as 60 per cent of our biodiversity depends on darkness to survive. Light pollution disrupts natural cycles of breeding, confuses bird migratory patterns and wreaks havoc on our insects. Ecologists have shown that in the UK, spring is appearing a whole week earlier due to light pollution. That's why the work we are doing in North Wales is so vital.

The policies we are creating will ensure our skies are protected from future light pollution and what's more, where possible, dark-sky-friendly lighting is being installed. Wales already has the highest percentage of protected dark skies anywhere in the world (17.61 per cent).

When the AONBs of Anglesey, Llŷn Peninsula and the Clwydian Range and Dee Valley receive their designations, an impressive 22.9 per cent will be protected. And they say Wales is stuck in the dark ages like it's a bad thing!

Dani Robertson is a Dark Sky Officer for Snowdonia National Park and three Areas of Outstanding Natural Beauty. Find out more on **@ProsiectNos** on Twitter and Facebook

ELENI DEBO/FOLIO

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BBC Sky at Night MAGAZINE

Insight Investment Astronomy Photographer of the Year

BBC Sky at Night Magazine proudly announces the 2020 victors of the world's largest astrophotograpy competition

MORE ONLINE
A gallery of these and more stunning images from the competition

OVERALL WINNER / GALAXIES

△ Andromeda Galaxy at Arm's Length?

Nicolas Lefaudeux (France)

Photo location: Forges-les-Bains, Île-de-France, France, 2–3 September 2019

Equipment: Sky-Watcher Black Diamond 100mm apochromatic refractor telescope at f/9, iOptron iEQ30 mount, Sony ILCE-7S camera (modified), ISO 2000, 2 hours 30 minutes total exposure

Judge's verdict: "To most of us, our closest neighbouring galaxy, Andromeda, can also feel so distant and out of reach. Yet to create a photograph that gives us the impression that it is just within our physical grasp is truly magical. It's a masterful image of the Andromeda Galaxy with a fine consideration to colour, detail and composition that makes this photograph such a worthy overall winner. I also commend the technical commitment of the photographer to capture the authentic 'tilt-shift focus' effect by creating a bespoke 3D-printed mount between their camera sensor and telescope. This image has certainly been my favourite in this year's competition and also one that gives me a big smile every time I view it." **– Ed Robinson** ▸

OUR SUN

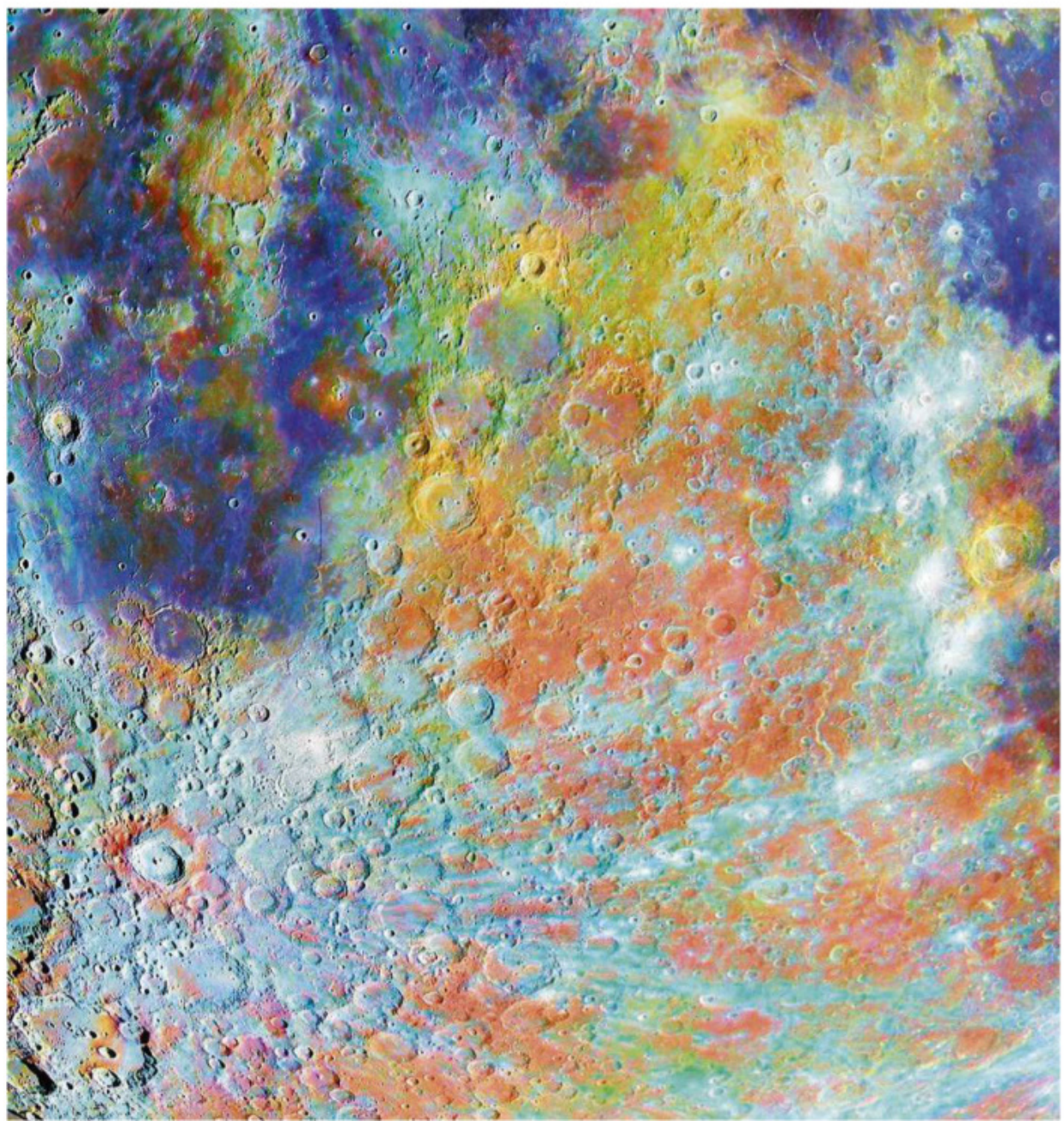
△ Liquid Sunshine

Alexandra Hart (UK)
Photo location: Holmes Chapel, Cheshire, UK, 21 April 2019
Equipment: Celestron C11 XLT Schmidt-Cassegrain telescope at f/50, Baader AstroSolar ND3.8 Continuum filter, Sky-Watcher EQ6 Pro mount, ZWO ASI174MM camera, 8.431-millisecond exposure
Judge's verdict: "This is a stunning example of how the 'quiet' Sun is never truly quiet. While the Sun may be less active, the ongoing nuclear fusion below its surface sustains all life on our little world." **– Emily Drabek-Maunder**

OUR MOON

Tycho Crater Region with Colours ▷

Alain Paillou (France)
Photo location: Couternon, Côte-d'Or, France, 16 March and 18 April 2019
Equipment: Celestron C9.25 telescope at f/10 and f/6.3, Orion Sirius EQ-G mount, ZWO ASI178MM and ASI178MC cameras, multiple 15-millisecond exposures
Judge's verdict: "The Moon is not as silvery grey as it seems. This vibrant image teases out the faint colours on the lunar surface. Not only is this composition visually striking, but it highlights the different materials the Moon is made up of, all from the safety of Earth." **– Emily Drabek-Maunder**



PEOPLE AND SPACE

The Prison of Technology ▷

Rafael Schmall (Hungary)
Photo location: Kaposfő, Southern Transdanubia, Hungary, 26 December 2019
Equipment: Sky-Watcher Quattro 200/800 astrograph telescope (modified) at f/4, Sky-Watcher EQ6-Pro Go-To mount, Canon EOS 6D, ISO 1600, 5 x 150-second exposures
Judge's verdict: "Sometimes beauty reveals an unattractive truth. This picture is as aesthetically pleasing as it is shocking. How far must [satellite constellations] go before we realise how we are altering our precious connection with our night sky?"
– Melanie Vandenbrouck

SIR PATRICK MOORE PRIZE FOR BEST NEWCOMER

△ Waves

Bence Toth (Hungary)

Photo location: Gödöllő, Pest County, Hungary, 30 November 2019
Equipment: Sky-Watcher Quattro 200P telescope at f/4, Sky-Watcher EQ6-R mount, ZWO ASI1600MM Pro camera, RGB-Ha-SII composite, 7 hours 50 minutes total exposure
Judge's verdict: "What a truly magnificent detail of one region of the California Nebula, a view of the nebula that is new to me. The region has been chosen effectively, nicely illustrating what the photographer intended. The processing is excellent, drawing out the detail and enhancing the structure to give a 3D impression of the crest of a huge wave ready to crash down." **– Mandy Bailey** ▸

PLANETS, COMETS AND ASTEROIDS

◁ Space Between Us...

Łukasz Sujka (Poland)
Photo location: Budy Dłutowskie, Łódź Voivodeship, Poland, 31 October 2019
Equipment: Sky-Watcher Newtonian 10-inch telescope at f/4.8, Baader MPCC Coma Corrector filter, Sky-Watcher NEQ-6 mount, ZWO ASI178MM-C camera, 300 x 10-millisecond exposures per channel
Judge's verdict: "While judging in times of lockdown and social distancing, this picture took on a particular poignancy. It was a healthy reminder, too, that scale and space is also a question of perspective."
– Melanie Vandenbrouck

AURORAE

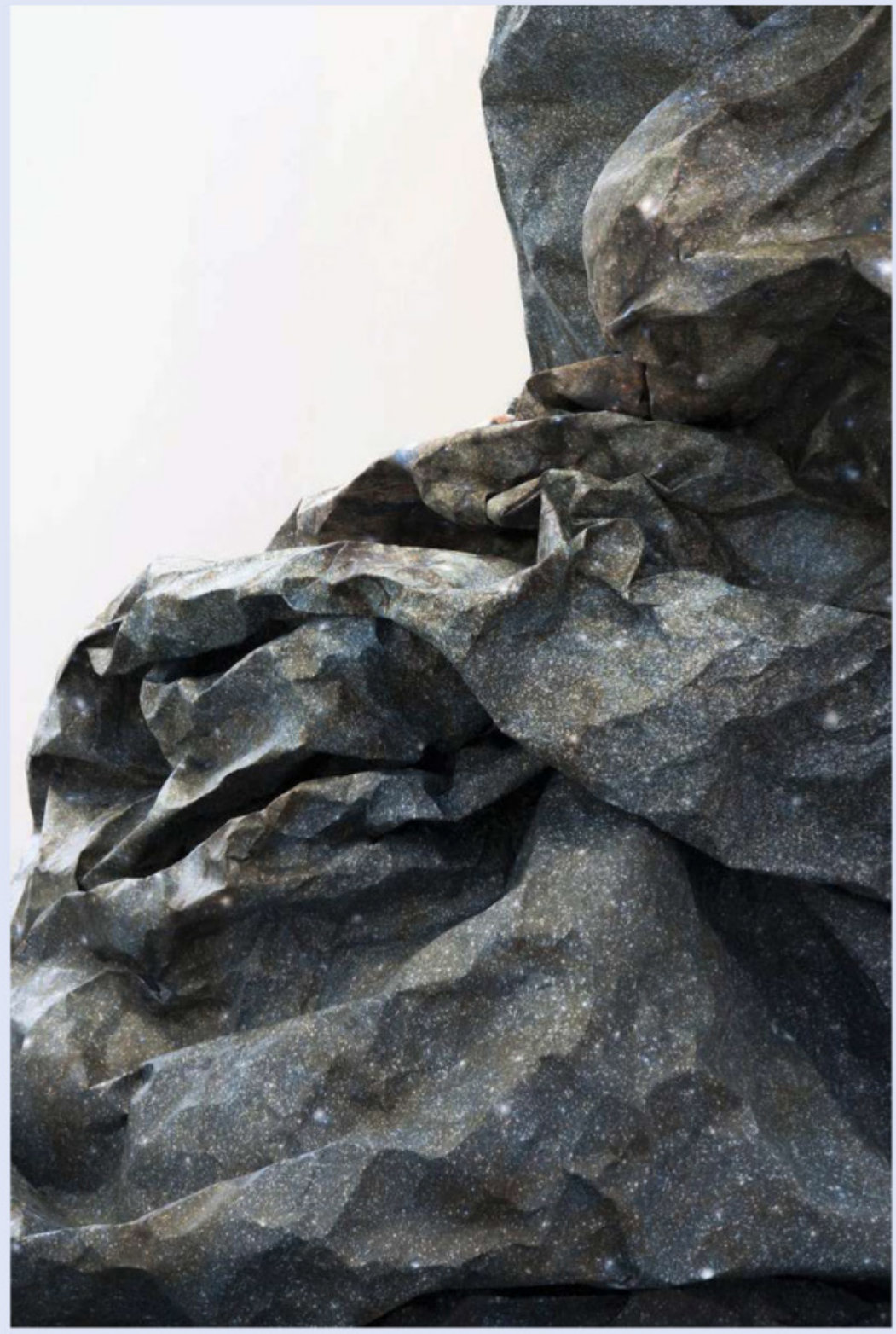
▽ The Green Lady

Nicholas Roemmelt (Germany)

Photo location: Hamn i Senja, Skaland, Norway, 25 March 2019
Equipment: Canon EOS R camera, 14 mm f/1.8 lens, ISO 6400, 4 x 1.6-second exposures
Judge's verdict: "This was such a dramatic image, with the 'Green Lady' appearing to take flight above the mountains and the illuminated water's edge. I liked the way the landscape was dwarfed by the dominant aurora and yet the forms and colours of the composition echoed above with below. This was definitely one of my favourite images in this year's competition."
– Susan Derges

ANNIE MAUNDER PRIZE FOR IMAGE INNOVATION

Dark River (Detail) ▷

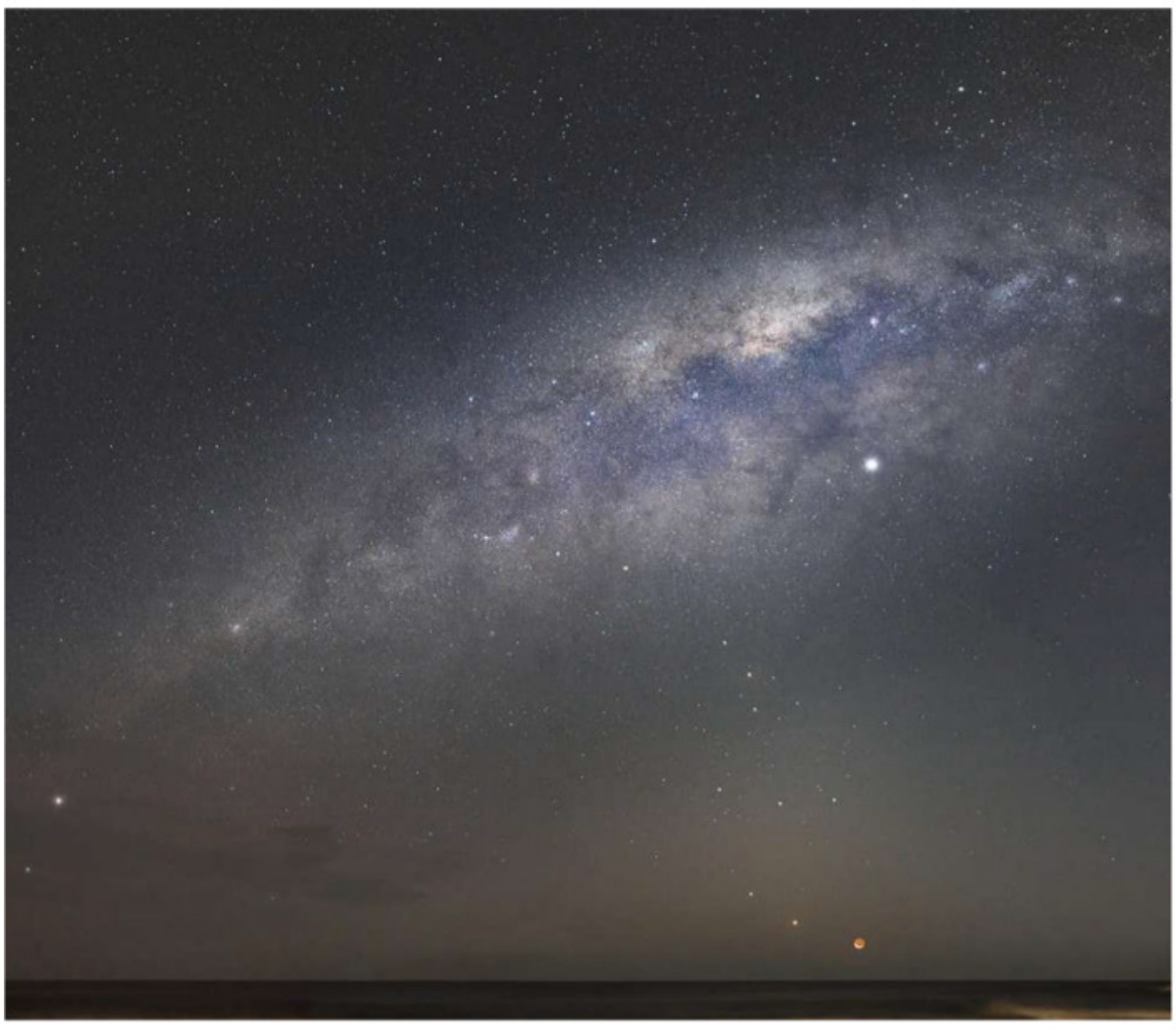


Julie Hill (UK)
Data source: VISTA Survey Telescope, Paranal Observatory, Chile, Infrared J 1.25 µm, Infrared H 1.65 µm, Infrared 2.15 µm channels, ESO/VVV Survey/D. Minniti.
Acknowledgement: Ignacio Toledo, Martin Kornmesser

About the category: "The Annie Maunder Prize for Image Innovation is a new category with a different focus – entrants don't have to be experienced astrophotographers. Instead we asked them to use publicly available images from research telescopes and remix the data, encouraging them to innovate.

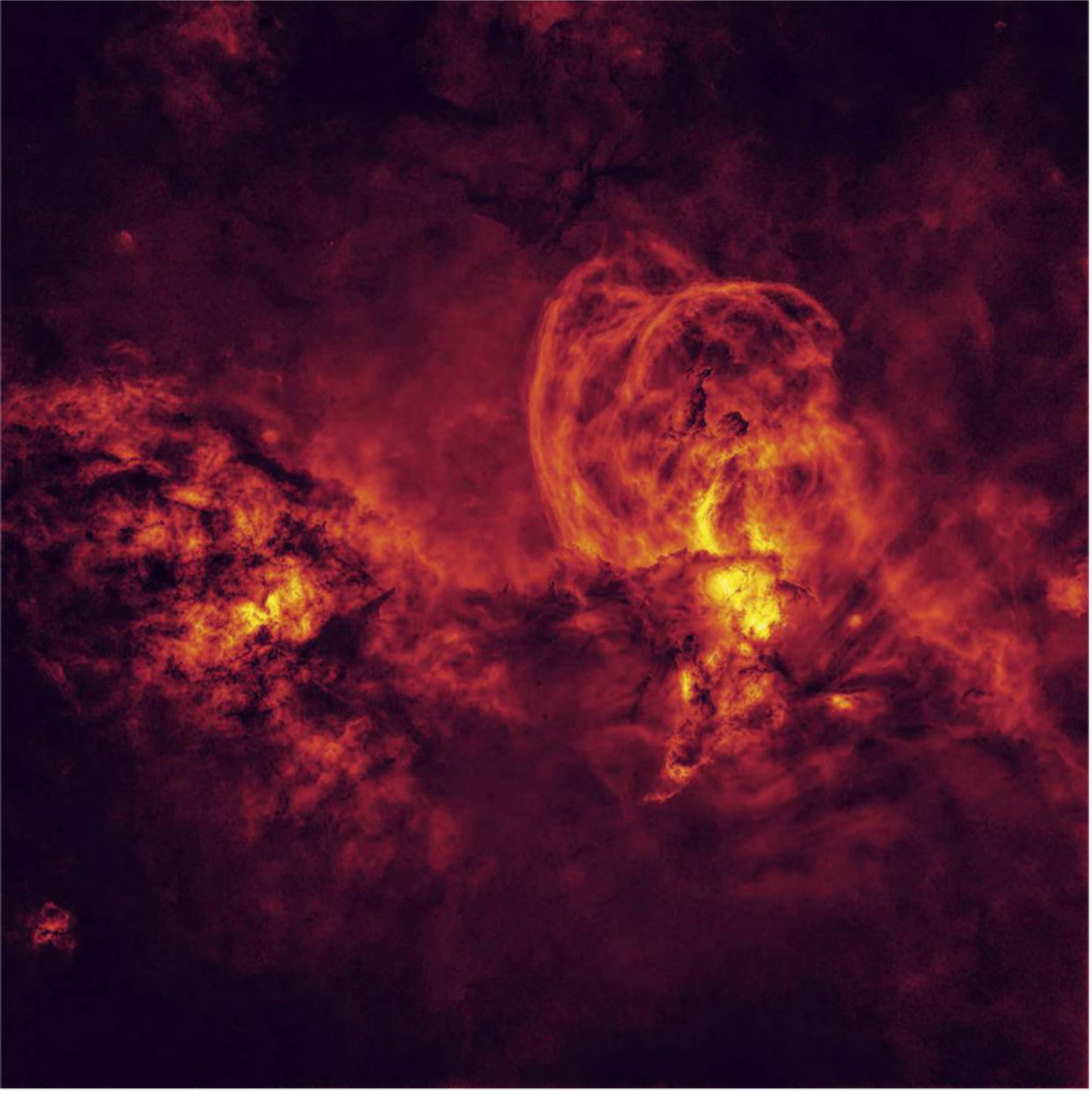
The images in the category are outstanding and the entrants rose to the challenge with innovative images from telescopes around the world. One image, 'The Heart of the Crab', gives a unique perspective of a supernova remnant, the Crab Nebula, by combining different kinds of light – visible, infrared and X-ray. It allows us a glimpse into this region of space, from the spinning pulsar at the nebula's centre to the hot leftover dust and gas from the supernova explosion. The winner (right) was one of the most creative entries we had in this year's competition. Julie Hill printed images from Paranal Observatory in Chile to create a physical representation of the 'river' of our Milky Way. She created a sculpture that allows the viewer to experience our Galaxy in three dimensions."
– Emily Drabek-Maunder

YOUNG COMPETITION



◁ The Four Planets and the Moon

Alice Fock-Hang, aged 10 (France)
Photo location: L' Étang Salé, Réunion, France, 29 October 2019
Equipment: Nikon D610 camera, 35mm f/3.2 lens, ISO 3200, 18 x 13-second exposures
Judge's verdict: "A spectacular scene that is both wonderfully composed and professionally executed, with a fine artistic touch that looks like it could have been created by a seasoned astrophotographer. For a 10 year-old to create such a photograph is inspiring. I am excited to see what this young talented photographer creates in the future."
– Oana Sandu ▸



STARS AND NEBULAE

◁ Cosmic Inferno

Peter Ward (Australia)
Photo location: Barden Ridge, New South Wales, Australia, 10 November 2019
Equipment: Alluna Optics RC-16 telescope at f/8, 5nm Ha filter, Paramount ME II mount, SBIG STX-16803 camera, 32 x 10-minute exposures
Judge's verdict: "This is a reminder and testament to the horrors that the photographer references during the Australian bushfires. As photographers and artists it is often the personal experiences and moments in our individual lives that we translate into our depictions of what we see and then represent to our audiences through our works."
– Ed Robinson

SKYSCAPES

Painting the Sky ▷

Thomas Kast (Germany)
Photo location: Kilpisjärvi, Enontekiö, Finland, 31 December 2019
Equipment: Nikon D850 camera, 120mm f/16 lens, ISO 64, 1/40-second exposure
Judge's verdict: "Clouds are said to be the bane of astronomers' lives, but they can also be the inspiration for a breathtaking astrophoto. These rare, incredibly high nacreous clouds reflect colour like oil does on water and this photographer has captured them perfectly. With subtle processing he has brought out the vibrant hues that can sometimes be seen in our skies." **– Steve Marsh**

Insight Investment

Astronomy Photographer of the Year

For over a decade, the Insight Investment Astronomy Photographer of the Year awards have helped to showcase the very best work of astrophotographers around the globe. The 2020 competition attracted an incredible 5,275 submissions from 1,064 entrants located all over the world, competing for the top prize of £10,000.

As always, the high standard of entries meant the judges had a challenging time picking the winners, especially for the new Annie Maunder Prize for Image Innovation.

You can see the winners for yourself at the National Maritime Museum from 23 October 2020, but be sure to pre-book your ticket and time slot online, as required by the museum's social distancing guidelines. Visit **www.rmg.co.uk/astrophoto** for details.

THE JUDGES

Mandy Bailey
Astronomy Secretary for the Royal Astronomical Society

Jon Culshaw
Comedian, impersonator and guest on *The Sky at Night*

Emily Drabek-Maunder
Astronomer and Science Communicator at the Royal Observatory Greenwich

Susan Derges
Contemporary British artist and photographer

László Francsics
Overall winner of the 2019 IIAPY competition

Steve Marsh
Amateur astronomer and Art Editor at *BBC Sky at Night Magazine*

Ed Robinson
Award-winning photographer, director, creative director and visual consultant

Rebecca Roth
Image Coordinator and Social Media Specialist at NASA's Goddard Space Flight Center

Alan Sparrow
Chair of the UK Picture Editors' Guild and Director of the UK Picture Editors' Guild Awards

Melanie Vandenbrouck
Curator of Art (post-1800) at Royal Museums Greenwich

Free 2021 calendar

Don't miss the December issue of *BBC Sky at Night Magazine* comes with a free 2021 calendar featuring the top images from the Insight Investment Astronomy Photographer of the Year 2020 competition. It goes on sale on 19 November.

Get to know the Red Planet: with Mars making its closest approach this month, there'll be plenty of wonderful features to discover

OBSERVE MARS AT ITS BEST

October's opposition of the Red Planet is the best opportunity to view the world for years to come. **Pete Lawrence** helps you make the most of it with a week-by-week guide to what may be visible on Mars's disc

At long last Mars's great opposition is upon us this month, and it's time to make the most of its closeness to Earth, as well as its brightness and height in the sky. In this feature we'll help you to maximise your telescope views of the Red Planet, with a guide to the Martian features that will be best to view each week. Two dates to mark on the calendar are when Mars comes closest to Earth, a distance of 62 million km, at 15:19 BST (14:19 UT) on 6 October, and a week later, on 13 October, when it reaches opposition. This year the Red Planet is also notable for reaching an altitude of around 42° from the UK and presenting a maximum disc size of 22.6 arcseconds; after 2020, we won't see Mars's apparent disc size exceeding 20 arcseconds again until 2033.

So, what will conditions be like on Mars during this opposition? It takes 687 days for the planet to orbit the Sun and go through its seasonal changes, experiencing two equinoxes and two solstices. A Martian equinox occurs when the Sun appears to cross Mars's celestial equator, while solstices represent the instant when the Sun is at its most northerly or southerly position in the Martian sky. We divide Earth's year into 12 months, but on Mars it's usual to refer to periods in the Martian year (and its seasons) in terms of solar longitude (Ls). This value is measured in degrees from the planet's northern hemisphere spring equinox.

The first Martian 'month' is considered to be the period between Ls=0–30°, the second between Ls=30°–60°, and so on. The northern spring equinox at Ls=0° is followed by the northern summer solstice at Ls=90°. The northern autumn equinox occurs at Ls=180° and the northern winter solstice at Ls=270°. Between October 1 and 31, Ls increases from 288° to 310°, Mars being in the grip of a northern winter, the southern hemisphere basking in summer sunshine. At this October's opposition, Mars's southern hemisphere will be tilted towards Earth.

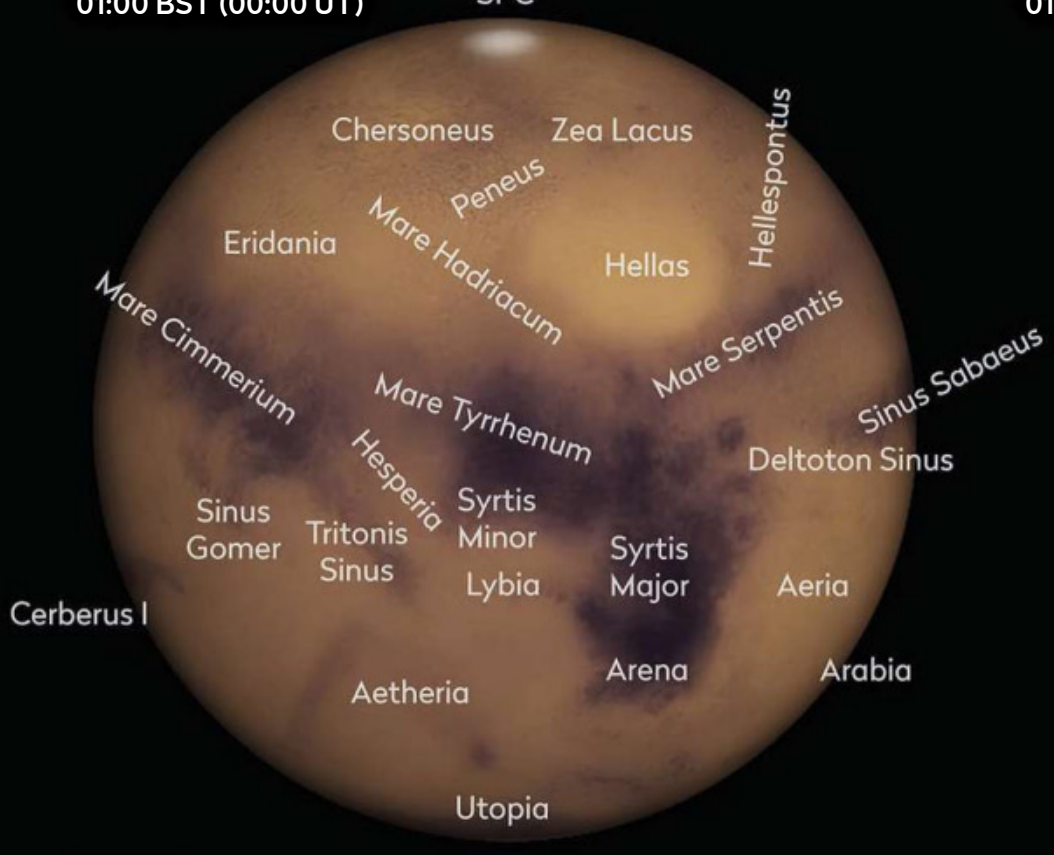
When it comes to observing around opposition, telescopes will show us dark and light regions on Mars's disc. These 'albedo' features are visible because of variations in reflectivity. The lighter regions generally represent desert areas, while the darker regions are exposed rock. In addition, the planet's polar caps shine bright. The south polar cap (SPC) should dominate our view, but as it's well into the southern summer, this will have shrunk to a fraction of its full size, the residual ice cap slightly offset from the planet's axis of rotation. The north polar cap (NPC) is currently beyond the northern limb of the planet, but the shroud of cloud currently covering it should be partially visible. This north polar hood (NPH) will dissipate as Mars enters northern spring in late January and February 2021.

As we begin, let's break the views up week by week during opposition month. Our descriptions are centred ▸

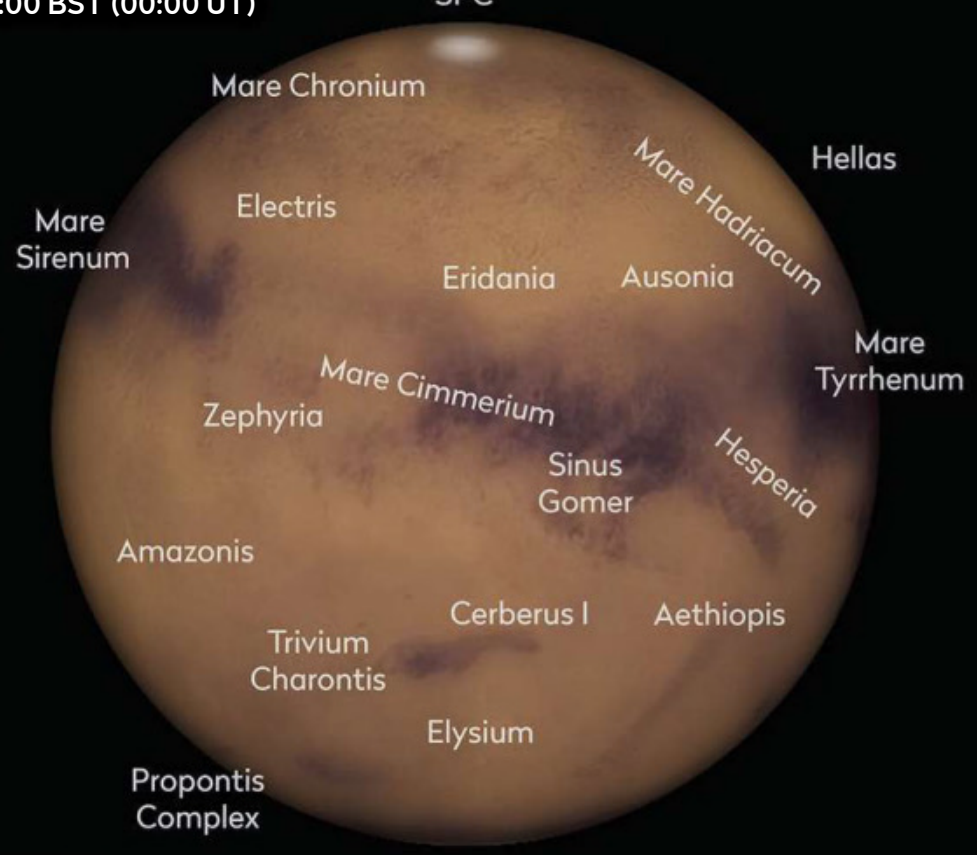
PETE LAWRENCE

"After this year we won't see Mars's apparent disc size exceeding 20 arcseconds again until 2033"

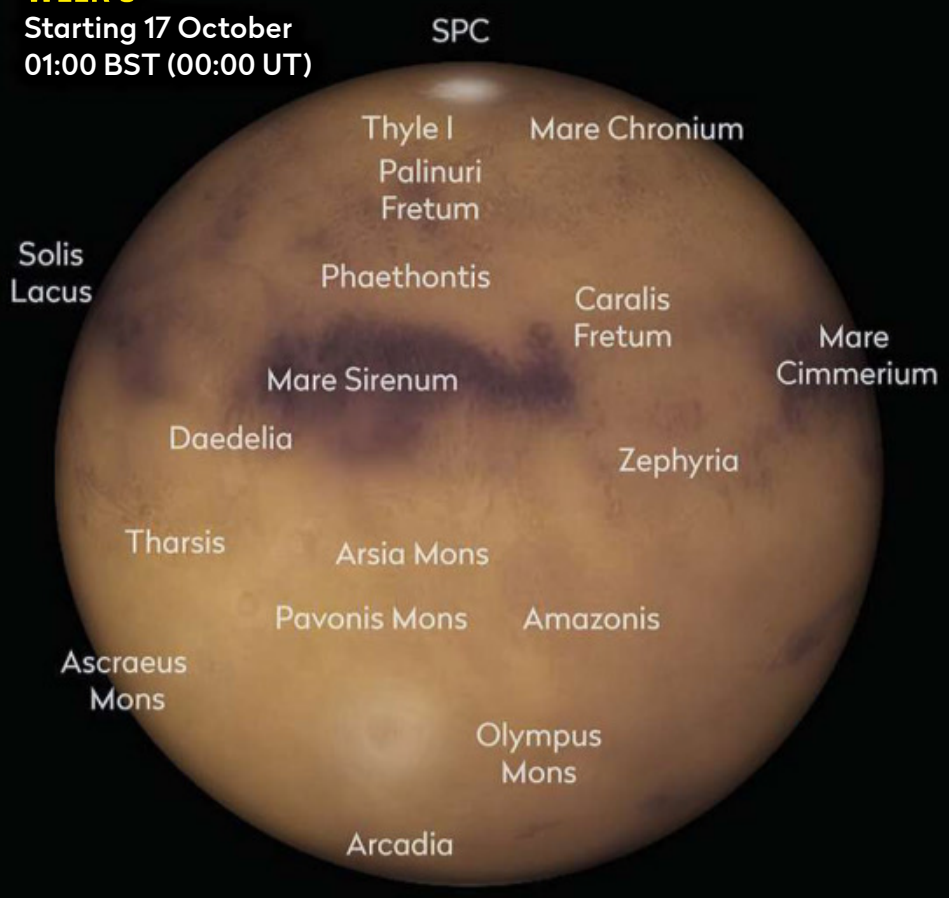
WEEK 1
Centred on 3 October
01:00 BST (00:00 UT)



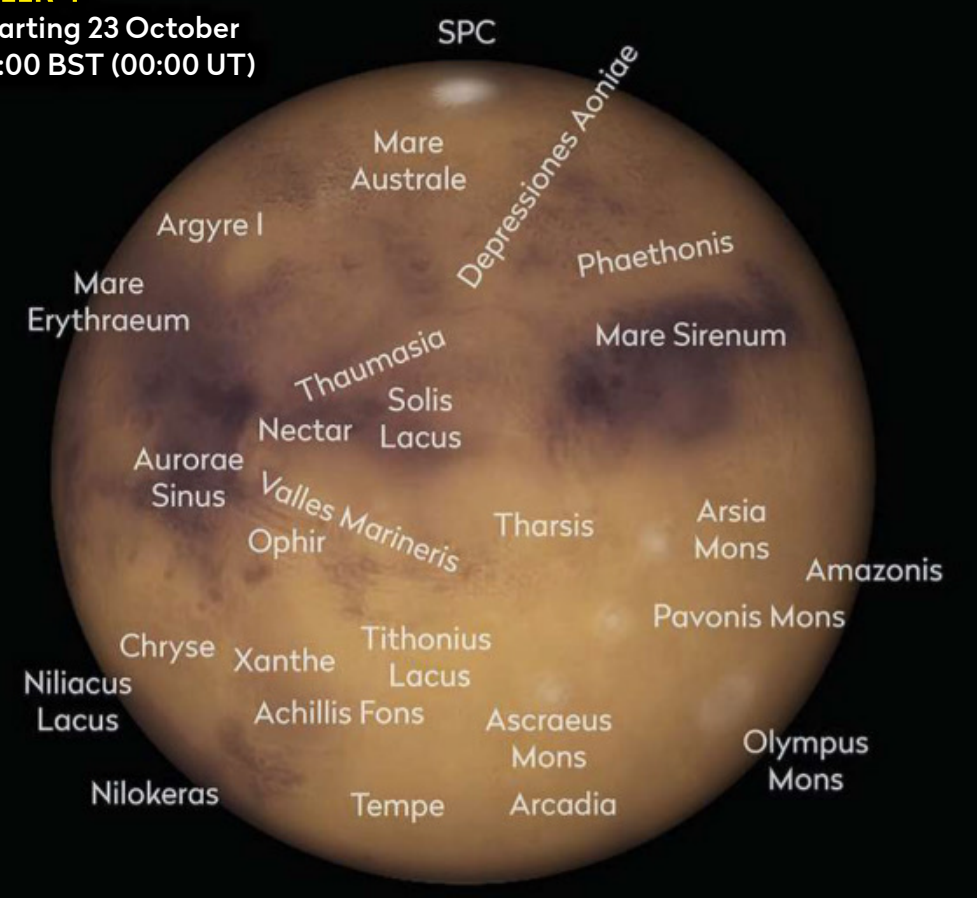
WEEK 2
Starting 10 October
01:00 BST (00:00 UT)



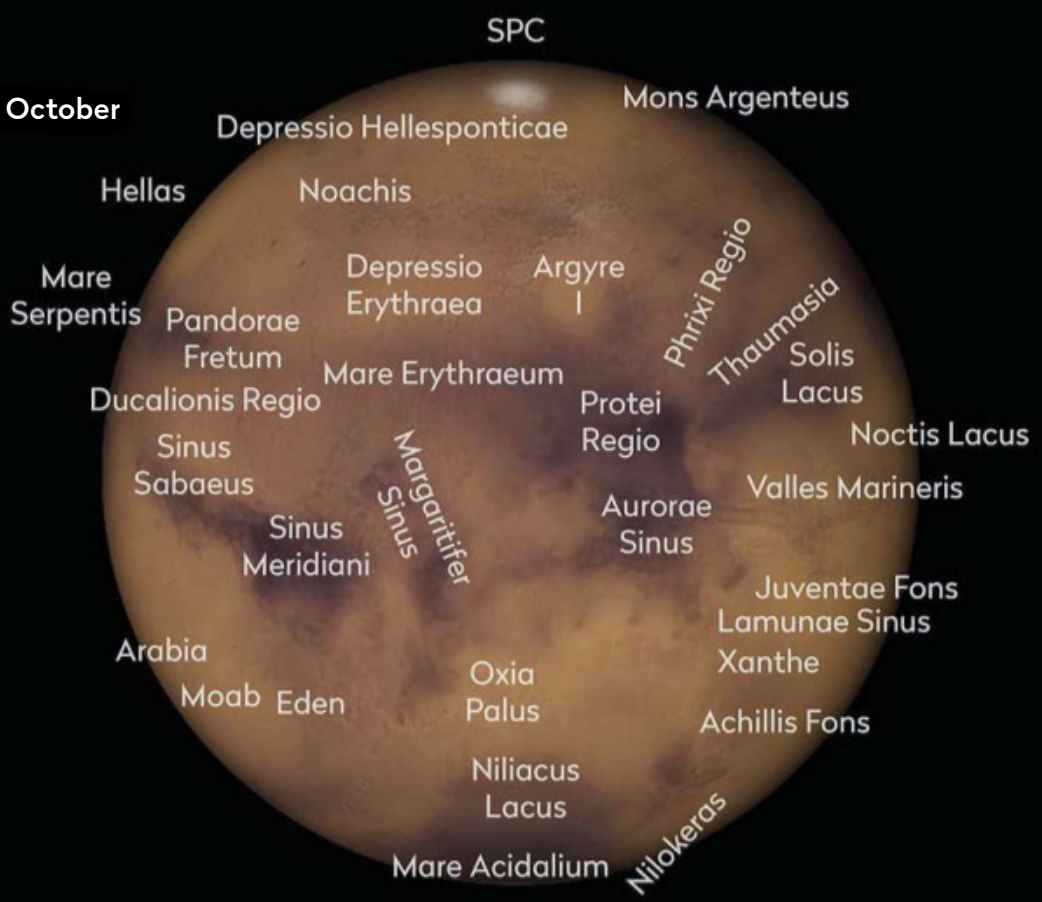
WEEK 3
Starting 17 October
01:00 BST (00:00 UT)



WEEK 4
Starting 23 October
01:00 BST (00:00 UT)

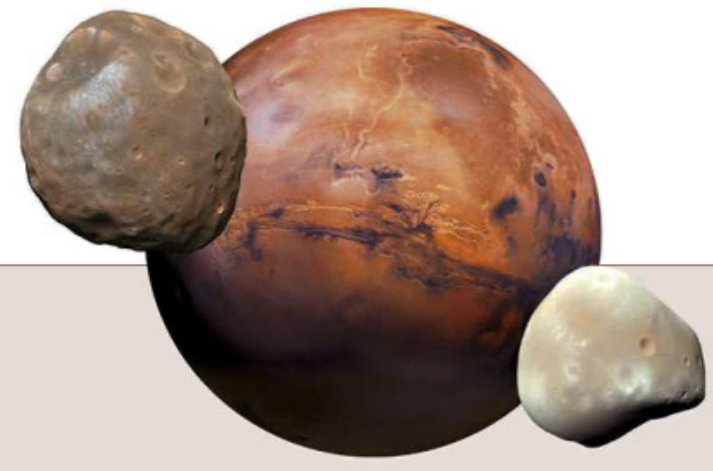


WEEK 5
Centred on 30 October
00:00 UT



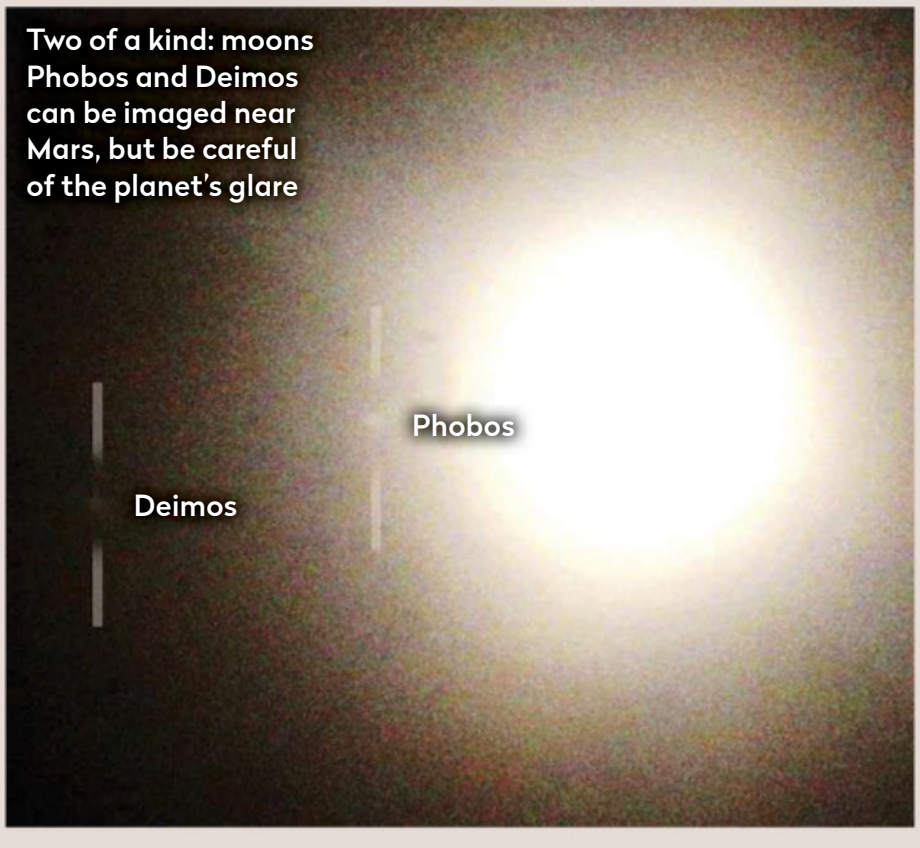
Tracking the Red Planet: during October the features visible on Mars each week change due to its rotation. In these south-up views the planet rotates right to left. A small telescope will show larger features, while scopes over 200mm will reveal further detail

S



The moons of Mars

The Red Planet's two small satellites are within reach of amateur scopes



Two of a kind: moons Phobos and Deimos can be imaged near Mars, but be careful of the planet's glare

Mars has two tiny moons. The largest is **Phobos**, which is 17 x 22 x 18km in size and orbits the Red Planet at a distance of 6,000km, taking 7 hours and 39 minutes to complete each orbit. **Deimos** is smaller, at 15 x 12 x 11km, and orbits Mars once every 1.26 days at a distance of 23,460km. Both moons are dim but well within amateur observing range, Phobos appearing at mag. +10.7, Deimos at +11.8. The problem with seeing or imaging them is Mars itself, which is very bright. That said, the best time to try is when the Red Planet appears greater than 20 arcseconds across.

The best strategy is to wait for the moon you are after to be close to an elongation – its furthest apparent distance from the planet. As the orbital periods are relatively short, these occur quite frequently. Use a freeware program like WinJupos (**jupos.org/gh/download.htm**) to determine when elongations take place and the best times to observe.

Using a high magnification or image scale is important to help see the moons. Their visibility may also be enhanced by using an occulting bar, a straight edge at the focal plane of your eyepiece (a piece of aluminium foil temporarily attached to this position is ideal). If you intend to catch the moons with a planetary camera, expect to overexpose the planet. However, you'll need to judge this carefully to avoid Mars's glare overpowering the scene.

PETE LAWRENCE X 5, NASA/JPL-CALTECH X 3

▸on 01:00 BST (midnight UT), the time when Mars will be at its highest. If you're observing away from this time, there'll be some variation in the visible features.

WEEK 1, CENTRED ON 3 OCTOBER (at 01:00 BST, midnight UT) reveals the most recognisable of all the Martian albedo features, the V-shaped Syrtis Major. It appears narrowest around Ls=190° (5 October) and in the past has shown seasonal changes. Following a major dust storm in 2001, the seasonal narrowing became more permanent. South of Syrtis Major lies the Hellas Basin and the brightness of this feature varies considerably; it's often filled with changeable 'weather'. Indeed, reflective frosts can trick you into thinking you are viewing the SPC rather than the basin. During the southern summer, Hellas is likely to be devoid of bright weather-related phenomena, but instead may provide a backdrop for invading dust storms.

A long, dark feature known as Rima Australis may be seen south of Hellas. This thin feature runs southwest of Hellas to skirt the southern edge of the SPC where it joins Magna Depressio. The dark line continues as Ulyxis Fretum before merging with Mare Chronium. As the southern summer approaches and the SPC recedes, its melting ice reveals an SPC remnant known as the 'Mountains of Mitchel', named after the Ohio astronomer Ormsby M Mitchel who first reported it in the 1840s. This region, known as Novissima Thyle, appears like a bright extension to the SPC, separated by Rima Australis.

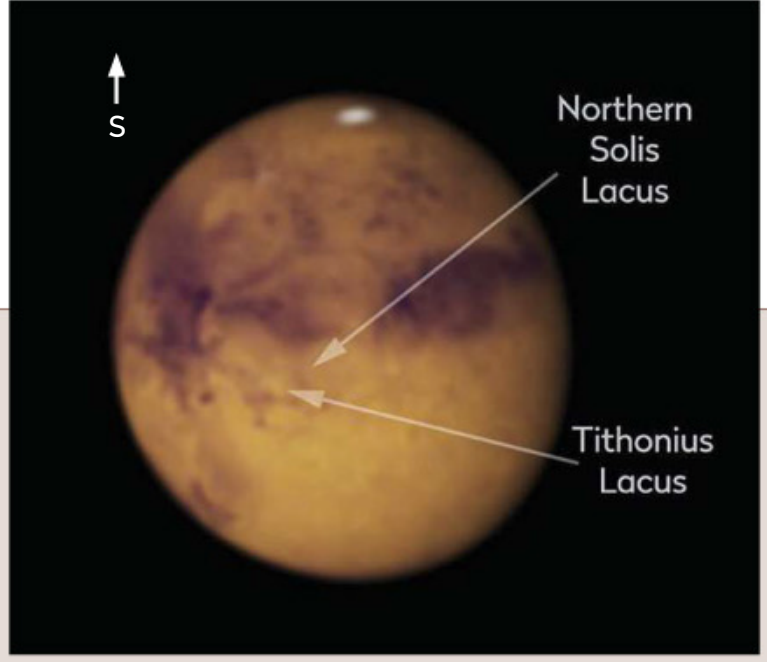
A similarly thin, long dark tract passes from the southernmost section of Rima Australis, where it merges with Magna Depressio, and runs west at a tangent to the SPC towards Mare Australe. This feature is Rima Augusta. The region between Rima Australis and Rima Augusta contains the bright Argenteus Mons, which can also look like a projection of the SPC.

Pete Lawrence is a skilled astro imager and a presenter of BBC Four's *The Sky at Night*. He writes for the magazine's Sky Guide found on page 43

WEEK 2, STARTING ON 10 OCTOBER (at 01:00 BST, midnight UT), will present a view of Mars that has rotated by 62° compared to the view from 3 October. This means that, as time progresses, Syrtis Major returns to centre stage once more. At midnight on 10 October, the distinctive dark twin prongs of Sinus Gomer appear near the centre of the Martian disc with Mare Cimmerium preceding (ahead of it as Mars turns), and Hesperia and Mare Tyrrhenum following it in the rotational order across the planet.

To the north is Elysium, which shows seasonal and long-term appearance variations. An interesting example of this is the Trivium Charontis region. This large, dark feature was prominent in the 1950s, but subsequently weakened in intensity as it became covered by dust and sand. It may appear as several darker spots in the desert; bright streaks, one running close to the northern limb, with another extended at right angles to it into Elysium, may also be seen in this view. The nature of these isn't fully understood.

WEEK 3, STARTING ON 17 OCTOBER (at 01:00 BST, midnight UT) brings us to what is sometimes unkindly described as the 'boring side' of Mars. At first glance it ▸



Martian flashes

More observations of mysterious transient bright spots on Mars's surface are needed

MARS FLARE PREDICTIONS: OCTOBER TO NOVEMBER 2020

TITHONIUS LACUS (–11°, 85°)	NORTHERN SOLIS LACUS (–15°, 90°)		
NOVEMBER	OCTOBER		NOVEMBER
20th 17:40 UT	14th 20:05 BST	26th 02:05 UT	19th 17:25 UT
21st 18:25 UT	15th 20:40 BST	27th 02:40 UT	20th 18:00 UT
22nd 19:00 UT	16th 21:20 BST	29th 03:55 UT	21st 18:40 UT
23rd 19:40 UT	17th 22:00 BST	30th 04:35 UT	22nd 19:20 UT
24th 20:20 UT	18th 22:35 BST	31st 05:15 UT	23rd 20:00 UT
25th 21:00 UT	19th 23:05 BST		24th 20:40 UT
26th 21:40 UT	20th 23:50 BST		25th 21:25 UT
27th 22:15 UT	22nd 00:30 BST		26th 21:55 UT
28th 22:55 UT	23rd 01:05 BST		27th 22:35 UT
29th 23:30 UT	24th 01:35 BST		28th 23:10 UT
December 1st 00:05 UT	25th 01:20 UT		29th 23:55 UT

Predictions assume horizontal reflectors; variations in orientation have been observed. Observe for 40–60 minutes either side of the stated time.

Interesting observations have been made in the past of transient brightening events – flares on the Martian disc. The most plausible explanation for these is that they are caused by spectacular reflections from ice, possibly in fissures or craters on the surface or from hydrated mineral areas.

Observing these fascinating events requires a 150mm or larger scope, high magnification and preferably good seeing. It also helps to know the general period when they may occur. Two reported sites are at Tithonius Lacus and Edom Promontorium, a region between Sinus Sabaeus and Sinus Meridiani corresponding to Schiaparelli crater. Our analysis suggests **Tithonius Lacus** and a site **north of Solis Lacus** may produce glints this apparition.

There is no guarantee that these 'ice glints' will be observable using predictions and they have only been recorded on a few occasions. There are still many unknowns about them, including whether any reflecting material forms seasonally, and what the variance is in the angles of the reflective surfaces which cause the glints. Positive observations are very useful for making future predictions.

Four values are used to determine possible events: declination of Earth (De) and Sun (Ds) from Mars, central meridian (CM) and the Earth–Mars–Sun phase angle (i). Our table (left) shows some dates and times when it's worth keeping an eye on the regions Tithonius Lacus and Northern Solis Lacus.

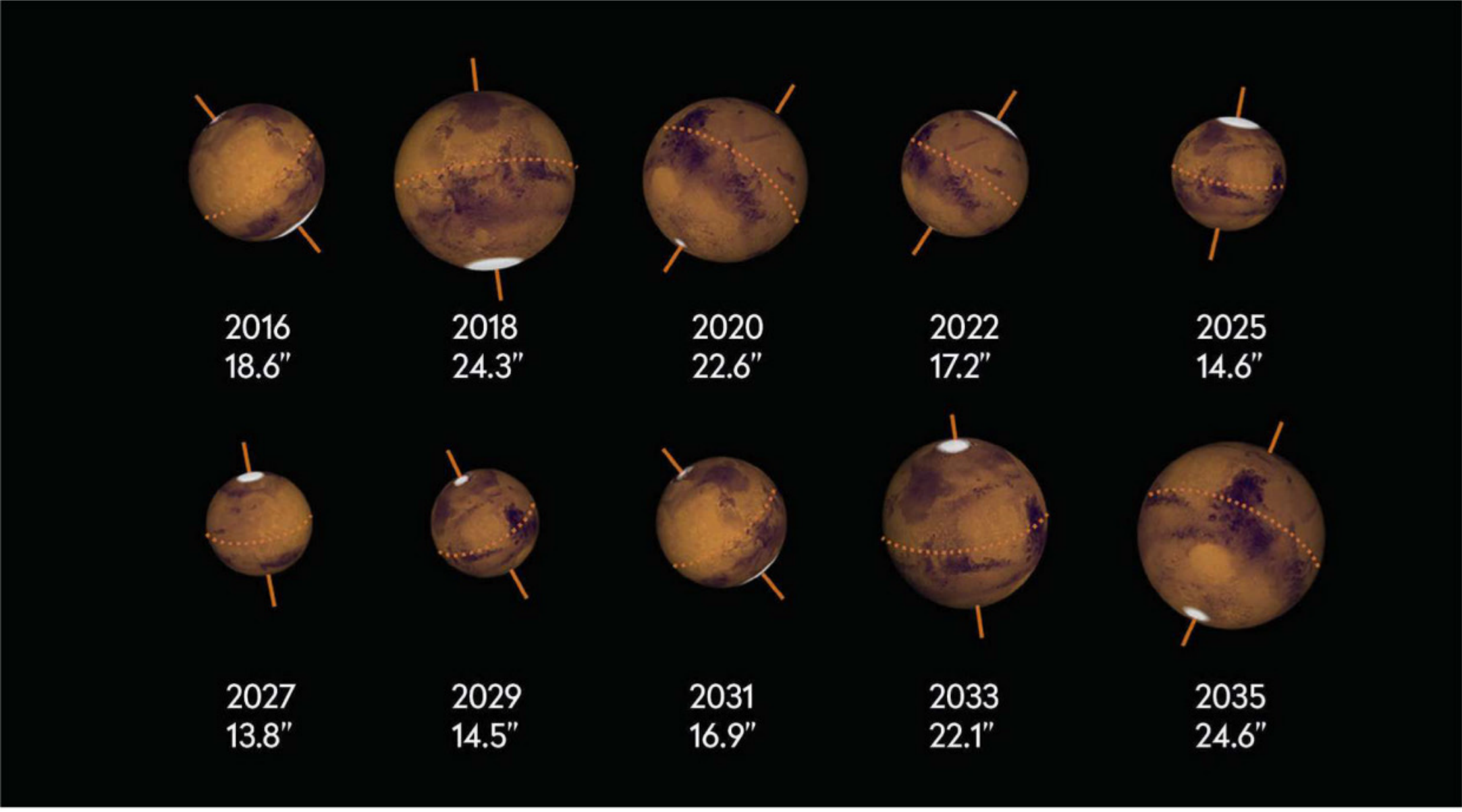
If a glint occurs it may present itself as a short-lived brightening in a region or a series of growing and dimming flashes. A flash may last for several seconds or even tens of seconds. Observing reports of these events may be done visually or using a camera. A photo sequence showing the flashes occurring at a high image scale would make a very valuable observation. Obviously, such a short-lived event means recording appearance times as accurately as possible, so it's important to keep an accurate timepiece to hand and to set the imaging computer's clock accurately.

ALL PICTURES: PETE LAWRENCE

▸ lacks complexity; dark albedo features are in short supply, apart from the rabbit-shaped profile of Mare Sirenum in the southern hemisphere. Of course, this side of Mars is anything but boring, giving us a look at the Amazonis and Tharsis regions, which contain the huge shield volcanos Ascraeus Mons, Pavonis Mons, Arsia Mons and Olympus Mons. The subtle desert tones are fascinating, as is the way Martian weather interacts with the volcanic peaks. Bright orographic clouds, such as the Arsia 'long cloud', sometimes betray their positions. Most notable during the northern summer (Ls=120°–160°), the clouds appear to form a recurring W-shaped pattern as sunset approaches the volcanos. It will be interesting to see whether this pattern repeats during the southern summer, given the equatorial positioning of the volcanos. If conditions are very good, careful observation may reveal the central caldera of giant Olympus Mons as a defined spot surrounded by a wider ring – the volcano's slopes

"The subtle tones of the desert regions are fascinating here, as is the way Martian weather interacts with the volcanic peaks"

WEEK 4, STARTING ON 23 OCTOBER (at 01:00 BST, midnight UT) brings us face to face with the enigmatic 'Eye of Mars', another area which has shown significant variation over the years. The region is centred on dark Solis Lacus surrounded by lighter Thaumasia, the overall effect resembling an eye. The eye's intensity varies over time and is affected by dust storms. Its northwest edge contains Valles Marineris, a 4,000km-long canyon system, 200km across at its widest point and 10km deep. By comparison, Earth's Grand Canyon is 446km long, 30km wide and 1.6km deep. Through amateur scopes the relief detail of the canyon is too small to be seen, but a hint of the canyon's shape can be deduced. The complex dark region north of Valles Marineris



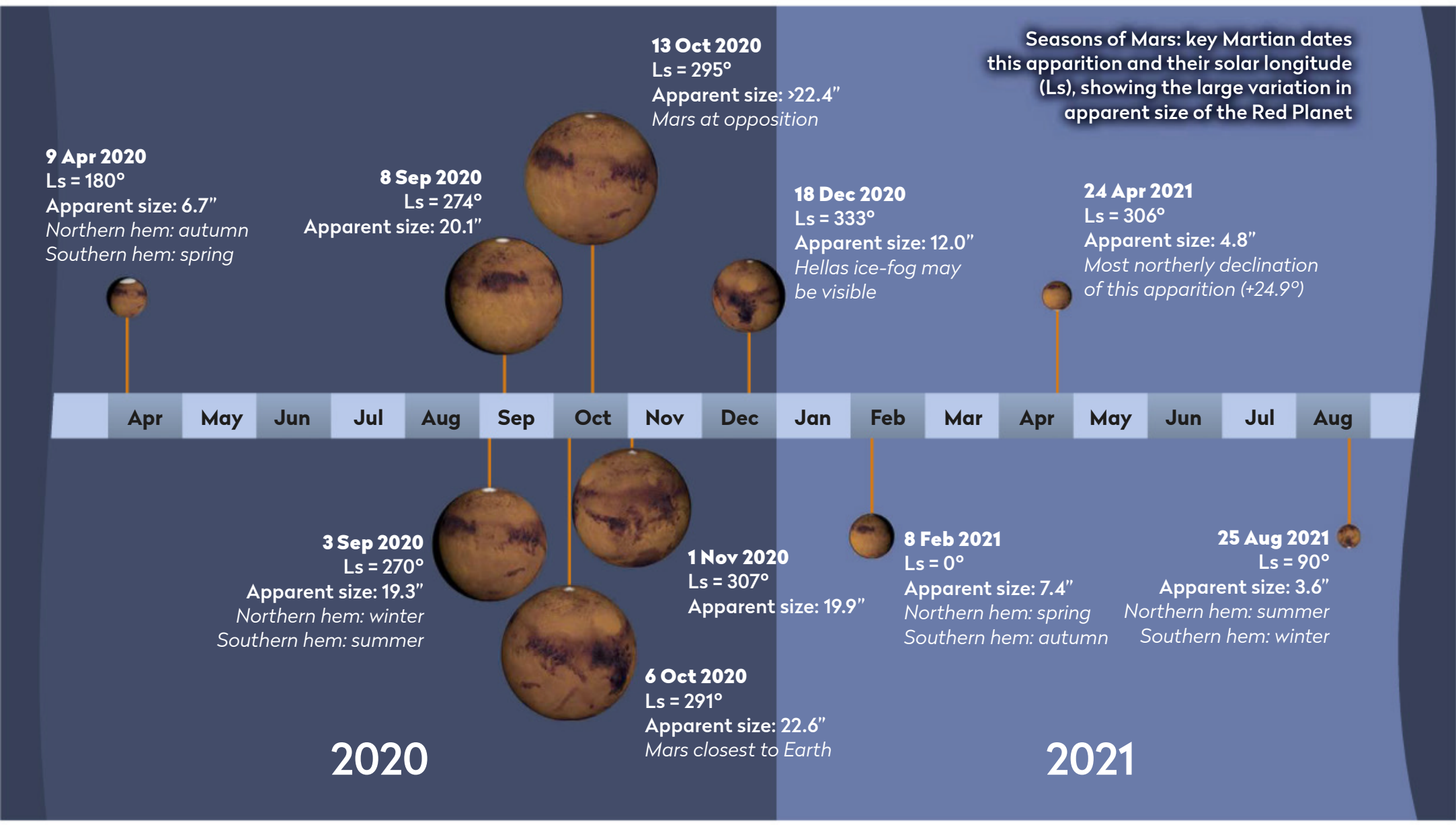
▲ Size matters: a comparison of Mars's apparent diameter when at opposition from 2016–35

includes Agathadaemon, Melas Lacus, Lus Lacus and Tithonius Lacus bordering the Ophir region to the north.

WEEK 5, STARTING ON 30 OCTOBER (at 00:00 UT), gives us a view of Margaritifer Sinus, with the complex 'fingers' of the Aurorae Sinus region following. The fingers appear to have darker spots at the end, which include Aurorae Fretum, Aromatum Promontorium and Juventae Fons.

So make sure you take advantage of this month's opportunity to view the fascinating world of Mars, when it's better presented than at any other time for years to come – and it'll be visible in the coming months after opposition too. Just think, when you view it through a scope you could be looking at a world which one day may have humans living on, or beneath, its surface.

▶ For more on Mars at opposition see page 48



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Satin Black

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16-PAGE CENTRE PULLOUT

BBC Sky at Night MAGAZINE

The Sky Guide

OCTOBER 2020

MARS REACHES OPPOSITION

Watch the Red Planet appear at its brightest and largest this month

PETE LAWRENCE

OBSERVING THE ORIONIDS

October's best meteor shower reaches its peak

TWO FULL MOONS

The first is a Harvest Moon, but is the second really a 'blue Moon'?

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Also on view this month...

- ✦ Discover the minor planet 11 Parthenope
- ✦ Explore the lunar crater Clavius
- ✦ Observe Uranus as it reaches opposition

Red light friendly

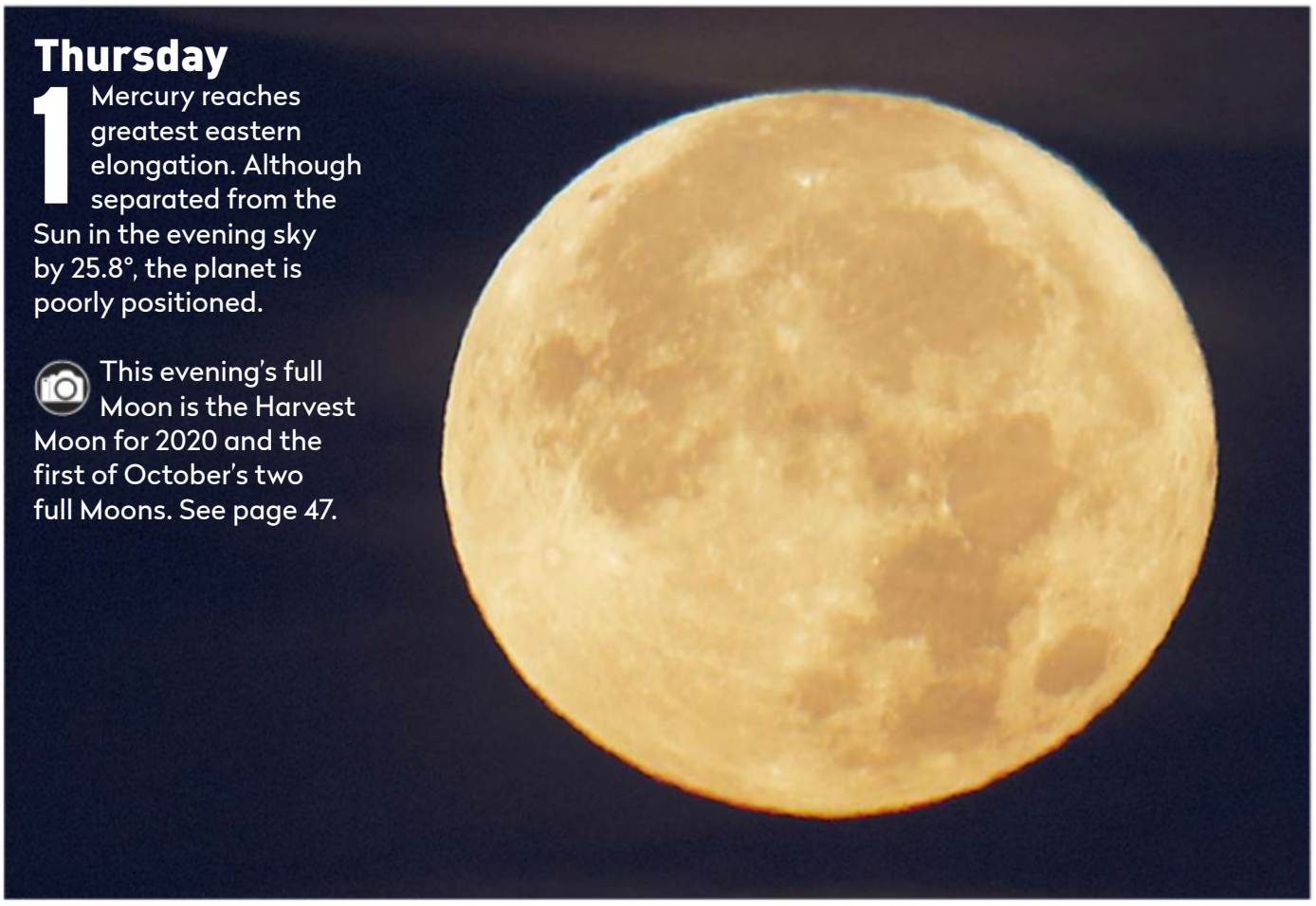
To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

OCTOBER HIGHLIGHTS

Your guide to the night sky this month



Thursday

1 Mercury reaches greatest eastern elongation. Although separated from the Sun in the evening sky by 25.8°, the planet is poorly positioned.

This evening's full Moon is the Harvest Moon for 2020 and the first of October's two full Moons. See page 47.

Saturday

3 A 98%-lit waning gibbous Moon and mag. –2.5 Mars appear very close at 06:00 BST (05:00 UT), separated by 1.1°.

Mag. –4.0 Venus is just 11.5 arcminutes from mag. +1.3 Regulus as they rise together after 03:30 BST (02:30 UT) .

Thursday

8 The Draconid meteor shower reaches its peak in daylight, but keep a look out during the first half of the night and you may spot these slow-moving meteors. Its peak ZHR (zenithal hourly rate) is usually 10 meteors per hour.

Tuesday

13 Mars reaches opposition and is in a very favourable position for observing from the UK. See page 48 for more.

◀ Wednesday

14 Mag. –3.9 Venus and a slender 10%-lit waning crescent Moon can be seen in the morning sky after 04:15 BST (03:15 UT). Look low above the eastern horizon where you'll see the pair separated by 3.7°.

Friday

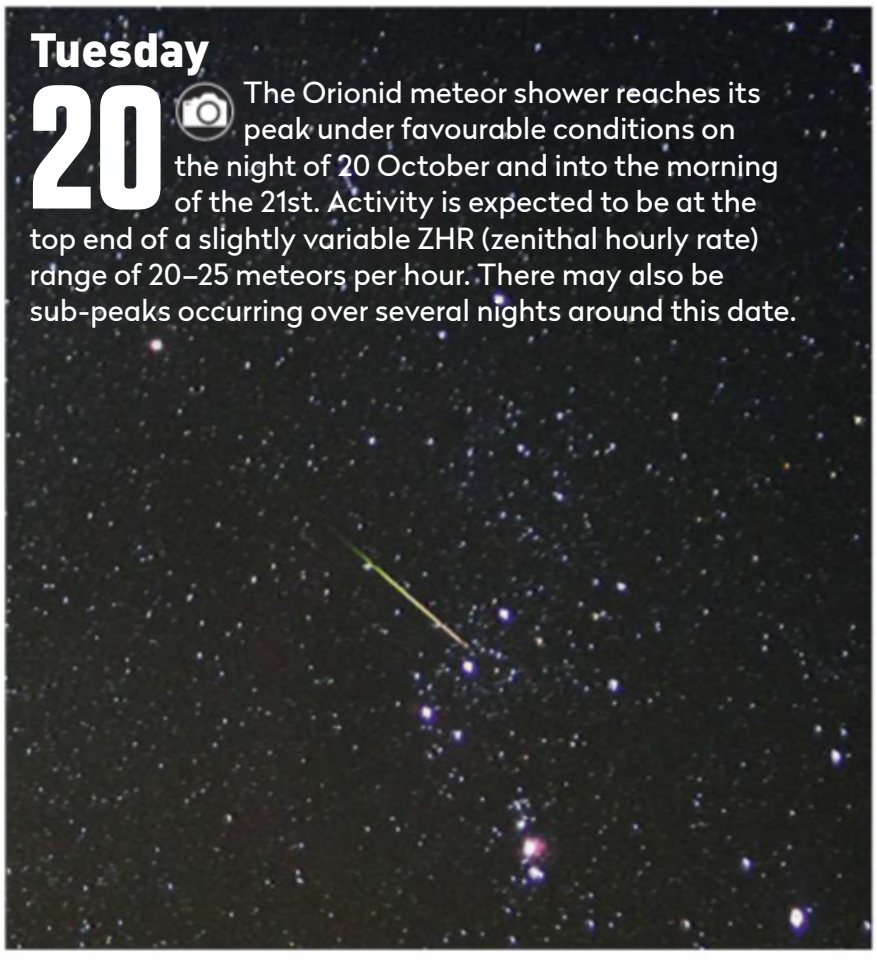
16 Today's less than 1%-lit waning crescent Moon is on what's known as the Danjon limit – the theoretical threshold below which a crescent Moon can't be seen visually. This tricky Moon rises slightly less than one hour before the Sun.

Saturday

17 This evening it's the turn of the evening sky to present a very thin crescent Moon. Can you spot the 1%-lit waxing crescent hanging low above the west-southwest horizon for just 30 minutes after sunset?

Tuesday

20 The Orionid meteor shower reaches its peak under favourable conditions on the night of 20 October and into the morning of the 21st. Activity is expected to be at the top end of a slightly variable ZHR (zenithal hourly rate) range of 20–25 meteors per hour. There may also be sub-peaks occurring over several nights around this date.



Family stargazing

October has two full Moons. Make a challenge out of trying to spot both of them, attempting to photograph them or sketch them. Both will be easy to see, appearing big and bright as they rise above the eastern horizon just after sunset. Explain that the Moon goes through a set of phases, taking 29.5 days to complete each cycle. Most months have only one full Moon and it's only when full Moon falls right at the start of a month that it's possible to fit another in before the end. Do a bit of research to find out when the next month with two full Moons will be. **www.bbc.co.uk/cbeebies/shows/stargazing**

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Tuesday ▶ 6

Mars is closest to Earth for its current period of visibility and presents its largest 2020 apparent diameter of 22.6 arcseconds. See page 48 for more.

Wednesday 7

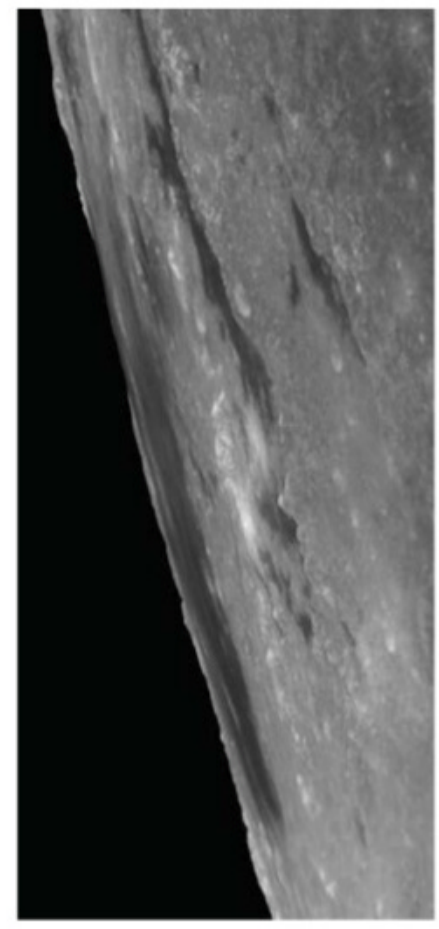
Ahead of the peak of the Draconid meteor shower on 8 October at 13:30 BST (12:30 UT), two additional periods of increased activity have been predicted for this morning at 02:25 BST (01:25 UT) and 02:57 BST (01:57 UT).

Saturday 10

Today marks the centre of the broad peak activity of the Southern Taurid meteor shower, which has a ZHR of 5 meteors per hour. Activity occurs from 10 September to 20 November.

Monday ▶ 12

Over the following mornings the waning crescent Moon has a good libration state (caused by the Moon's small rocking motion) showing features near the southwest limb, including the Mare Orientale impact basin.

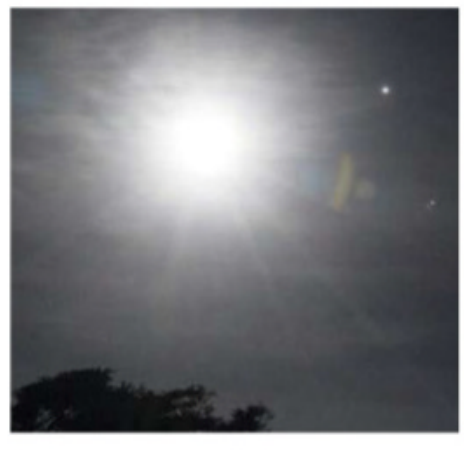


◀ Thursday 15

This morning, look low above the eastern horizon around 06:00 BST (05:00 UT). Below and to the left of Venus lies a thin 3%-lit waning crescent Moon.

Thursday ▶ 22

Mag. –2.1 Jupiter and a 41%-lit waxing crescent Moon are 3° apart this evening. Spot them low above the southern horizon from 19:00 BST (18:00 UT).



Sunday 25

British Summer Time ends this morning at 2am BST, when the clocks go back to 1am GMT (01:00 UT).

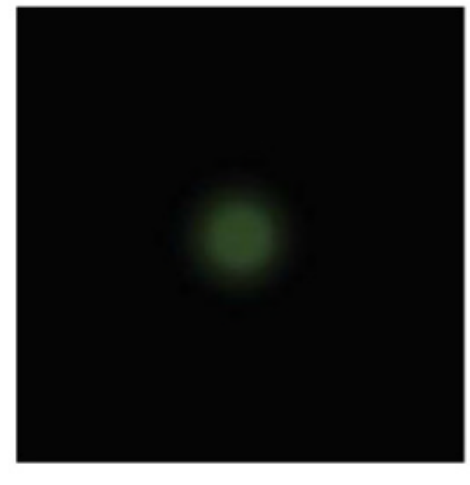
Thursday 29

This evening, mag. –2.2 Mars lies 3.5° north of the 96%-lit waxing gibbous Moon.

Saturday ▶ 31

A second full Moon in October occurs today. Although it's known in popular culture as a 'blue Moon', the Moon will not appear blue – see page 47 to find out more.

Uranus reaches opposition.



NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

THE BIG THREE

The three top sights to observe or image this month

DON'T MISS

OCTOBER METEORS

BEST TIME TO SEE:
20/21 October for the Orionids, 6/7 and 7/8 October for the Draconids, 10 October for the Southern Taurids

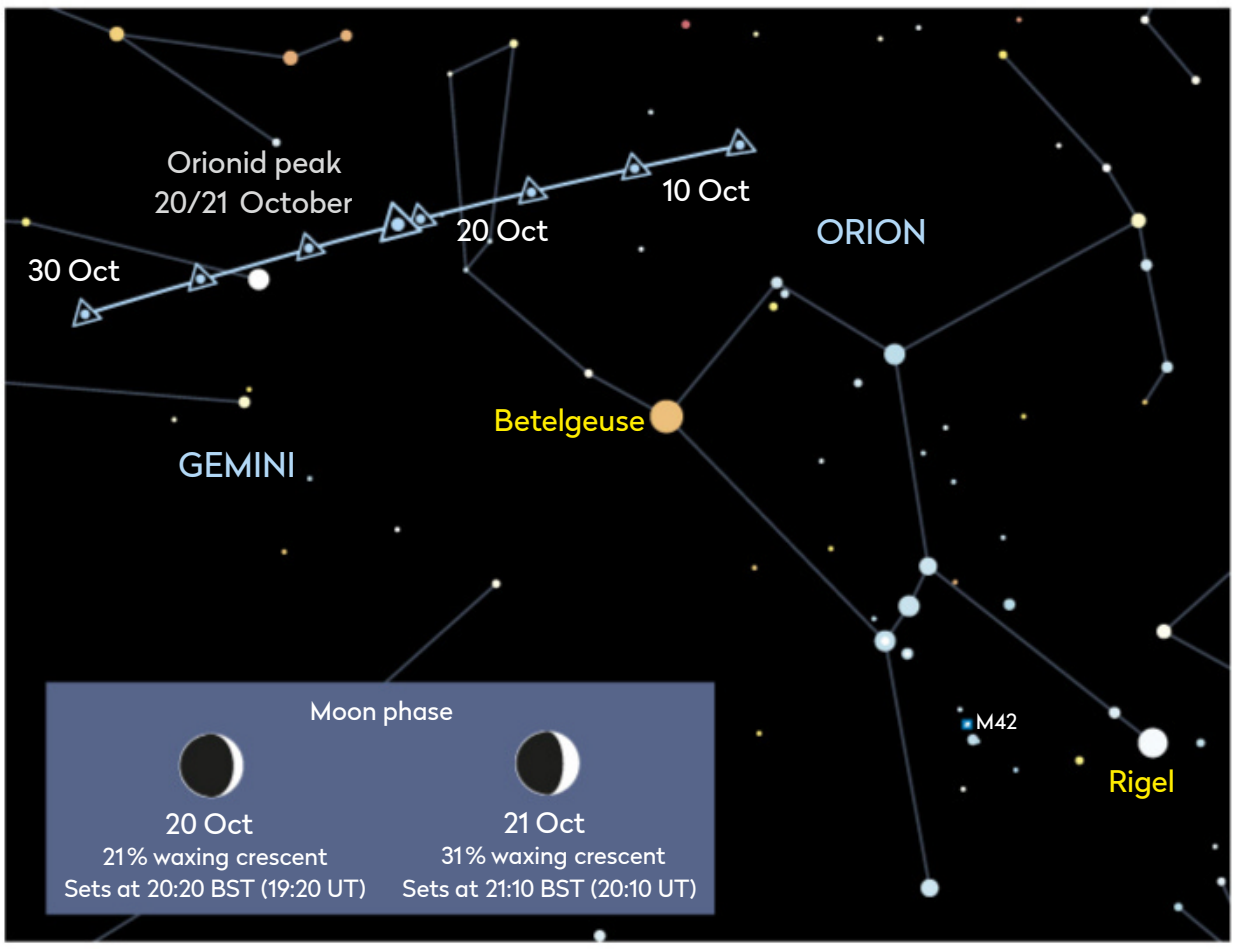
October is a good month for meteor activity. The main event is the Orionid shower, named because its peak activity has the shower radiant in Orion. A meteor shower's radiant is the position in the sky from where the shower meteors appear to emanate. In this case the Orionid radiant is near the star Betelgeuse in Orion.

Orionid activity tends to start around 2 October, building slowly to a peak, which this year occurs on the night of 20/21 October. The Moon will be largely out of the way this year, leaving the night sky good and dark for meteor watching. On the night of 20 October, the 21%-lit waxing crescent Moon sets around 20:10 BST (19:10 UT) and will not interfere further on peak night.

The Orionids are associated with comet 1P/Halley, the first such object to be determined as a periodic, or short-period, comet. Halley's comet returns to perihelion – it's closest point to the Sun, every 76 years, and was last in this position on 9 February 1986.

This month, the Orionid shower is expected to produce a ZHR (zenithal hourly rate) of around 25 meteors per hour, translating into a visual rate of 4–10 meteors per hour, depending on the quality of the night sky in your location. The peak night should produce the best results, but it's always worth keeping an eye out over the nights before and after as the Orionid shower has been known to exhibit sub-peaks.

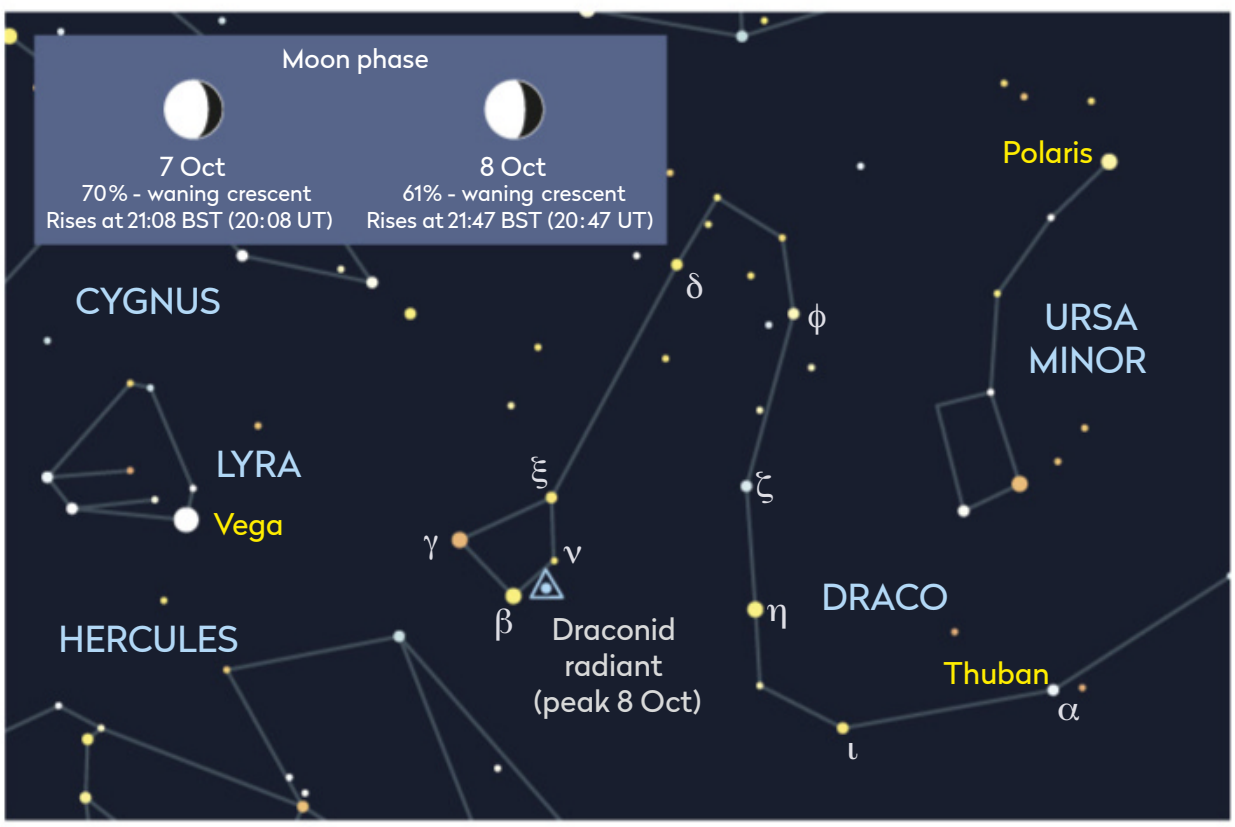
The Orionids is not the only shower active during October. The Draconid shower reaches its peak on the evening of 8 October, but there is also the possibility of two short outburst peaks,



▲ **The Orionid radiant appears near Betelgeuse and the shower's peak is on 20/21 October**

one at 02:25 BST (01:25 UT) and another at 02:57 BST (01:57 UT), both on 7 October. A bright Moon will interfere later in the night, but as the best time to view the Draconids is earlier in the evening, this should still allow a decent view. Typically, the Draconids produce a peak ZHR of 10 meteors per hour, but short-term boosts – up to 300 meteors per hour – have been seen in recent years. They are slow moving meteors with an atmospheric entry speed of 21km/s.

Another famous shower reaches a broad peak on 10 October. The Southern Taurid meteor shower has a peak ZHR of around 5 meteors per hour, but its broad peak persists over several days. It's part of the Taurid stream; with its Northern Taurid counterpart reaching peak activity on 12 November with a similar ZHR. The Taurids have shown fireball activity in the past, events due to slightly larger than normal debris in the stream. The parent comet for the Taurids is 2P/Encke.



▲ **The Draconid shower peaks on 8 October, with two possible short outbursts on the 7th**

ALL PICTURES: PETE LAWRENCE

A thin Moon spotting opportunity

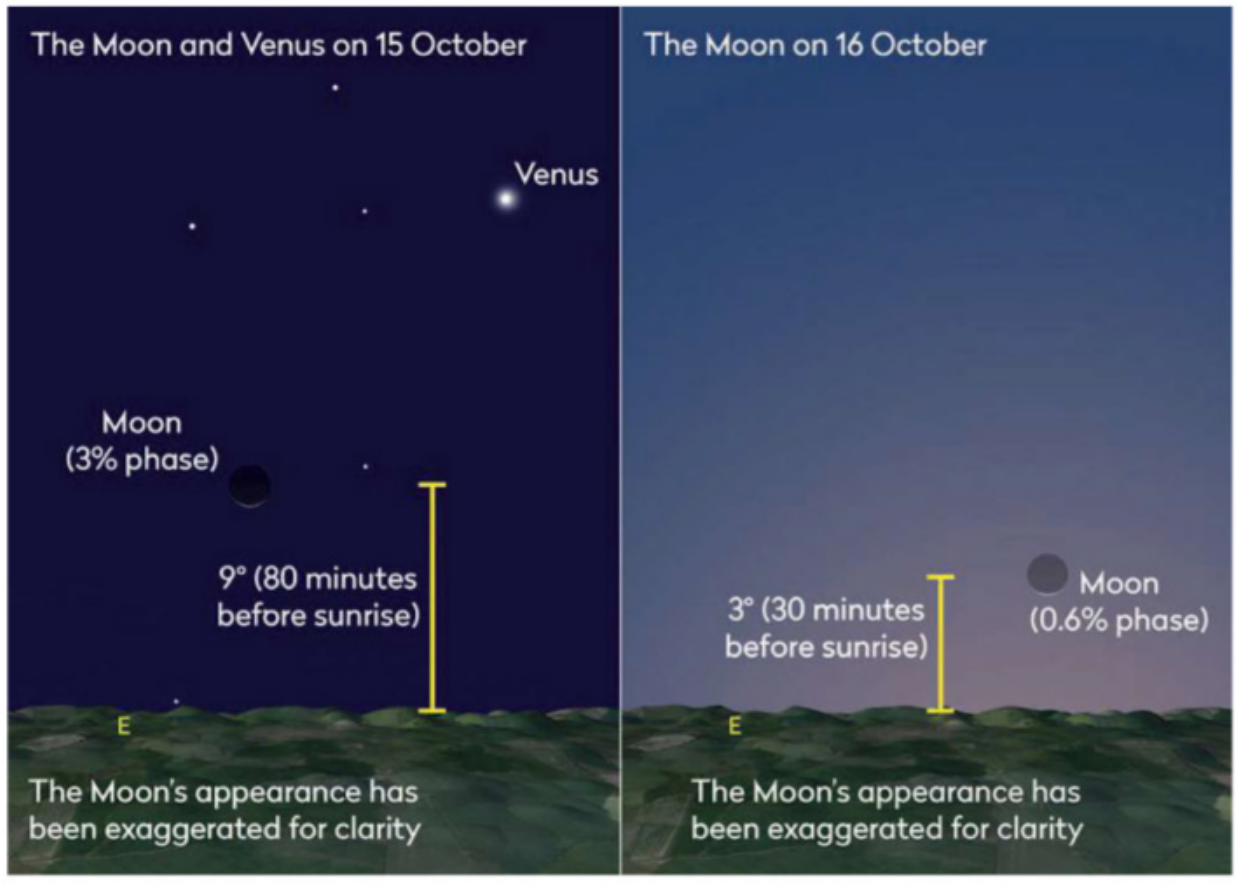
BEST TIME TO SEE: Mornings of 13–16 October

Venus is an impressive sight if you have clear morning skies, and the appearance of the planet near a thin crescent Moon is a wonderful sight. During the first part of 2020, Venus's evening appearances together with the thin waxing crescent Moon were widely seen. The morning apparitions are less popular because, to put it bluntly, you have to get out of bed to see them.

On the morning of 13 October, there's an excellent chance to spot a 17%-lit waning crescent Moon 12° from mag. –3.9 Venus. Catch them after 05:00 BST (04:00 UT) for the best view. The following morning around 05:00 BST (04:00 UT), Venus appears right of a now 9%-lit waning crescent Moon as seen from the UK. The separation has reduced significantly from the view on the 13th, Venus appearing 3.8° from the Moon on 14 October.

If the weather holds, look out for a very thin Moon on the morning of 15 October. Just before 06:00 BST (05:00 UT), with Venus high in the morning sky. Look for the Moon low above the east point on the horizon. It will be shining at just 3% illumination.

On the morning of 16 October, a less than 1%-lit Moon will be positioned 7.9° vertically above the position of the Sun. This means the apparent position of this thin crescent Moon is optimal for viewing, giving you the longest time difference between moonrise and sunrise. This particular Moon is 0.9° further from the Sun than the Danjon limit, the smallest apparent separation which theoretically allows the crescent Moon to be seen. It'll be a very hard spot, looking much fainter than a regular Moon. If you do manage to see or photograph it, you'll have observed a Moon just 13 hours before new Moon!



▲ **Observe a thin Moon near Venus on 15 October and vertically above the Sun on 16 October**

Not a 'blue Moon'

BEST TIME TO SEE: 1 & 31 October

There are two full Moons this month, one on 1 October and one on the 31st. Popular culture calls the second full Moon in a month a 'blue Moon', a term which has been misused over the years. The original *Maine Farmers' Almanac* definition of a blue Moon should refer to the third full Moon which occurs in a quarterly season of four; a season defined as winter solstice to spring equinox, spring equinox to summer solstice, summer solstice to autumn equinox and finally autumn equinox to winter solstice. If the original definition is adhered to, there is no blue Moon in 2020 as all four seasons only have three full Moons.

The full Moon on 1 October does have a formal title. The nearest full Moon to the Northern Hemisphere's autumn equinox is the Harvest Moon. This year the autumn equinox occurred at 14:30 BST (13:30 UT) on 22 September. The full Moon prior to this occurred at 06:22 BST (05:22 UT) on 2 September, 20 days, 8 hours and 8 minutes from the equinox. The full Moon on 1 October takes place 9 days, 6 hours and 36 minutes from the equinox, which defines the 1 October full Moon as the Harvest Moon for 2020.

If you're wondering how a full Moon is defined, it's to do with the position of the Moon in the sky relative to the Sun. When the Moon is full it's technically at opposition, meaning its ecliptic longitude must be 180° from the ecliptic longitude of the Sun.

► **October is bookended by two full Moons, appearing on the 1st and 31st**

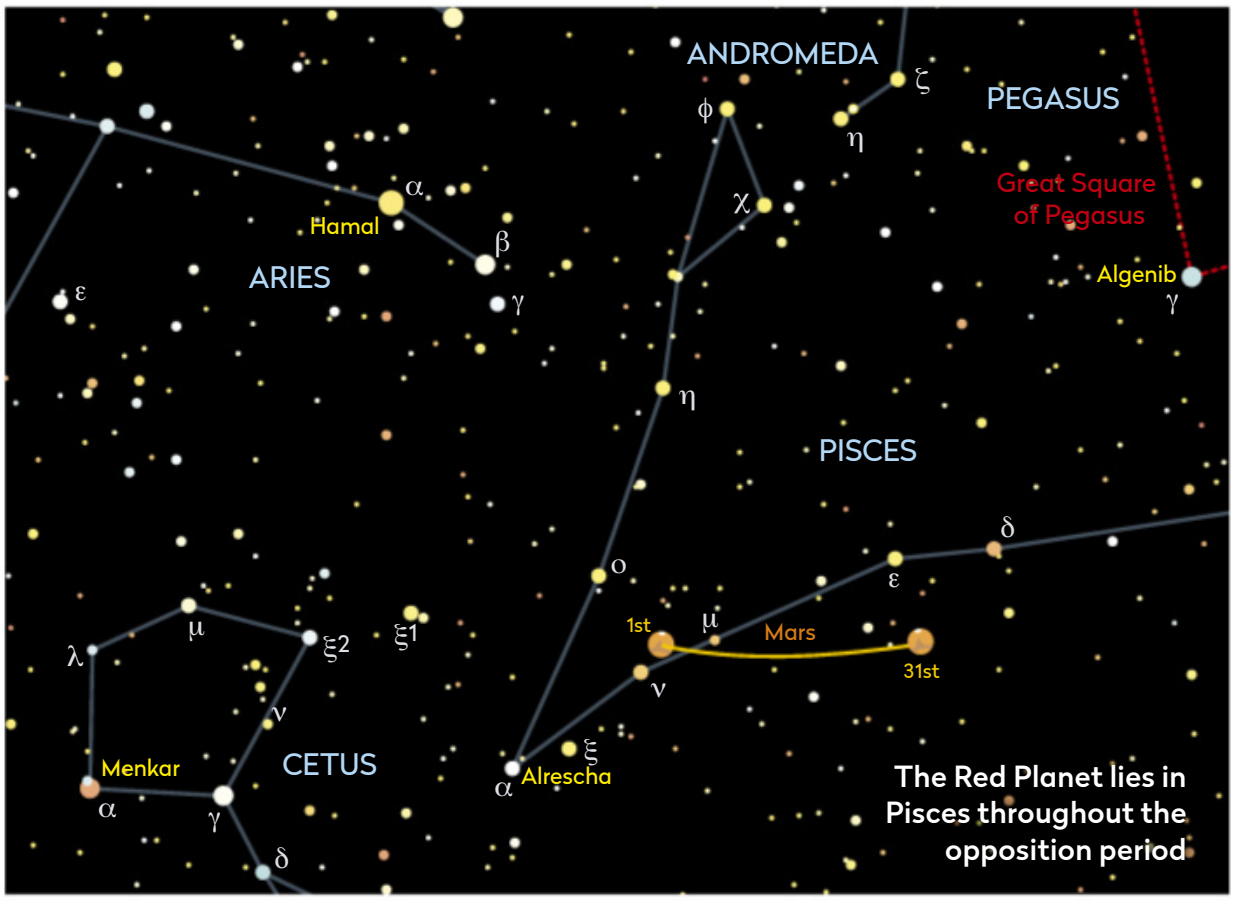
THE PLANETS

Our celestial neighbourhood in October

PICK OF THE MONTH

Mars

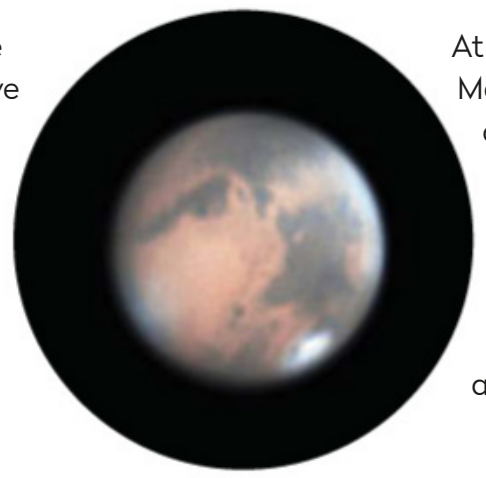
Best time to see: 6 October, around 00:30 BST (5 October, around 23:30 UT)
Altitude: 43°
Location: Pisces
Direction: South
Features: Dark 'albedo' features, polar caps, weather
Recommended equipment: 150mm or larger



The Red Planet lies in Pisces throughout the opposition period

Mars is at opposition this month, a time when the planet presents its best appearance through a telescope, and due to its brilliance, to the naked eye as well. Opposition occurs on 13 October, this being the time when the ecliptic longitude of the planet is 180° different to that of the Sun – in other words, Mars is in the opposite part of the sky to the Sun. However, technically the best views are to be had when Mars is closest to Earth, a position which is reached on 6 October. In reality of course, the presentation of Mars should be excellent for the weeks running up to and from opposition.

On 6 October, Mars will present a fully illuminated disc, 22.6 arcseconds across. Reaching its highest point in the sky around 00:40 BST (23:40 UT), a telescopic view of Mars from this time into the early hours will have the large, dark V-shaped feature known as Syrtis Major rotating into view. Syrtis Major is placed centrally around 04:20 BST (03:20 UT) on 6 October. Mars currently has its southern pole tilted towards us and this may be seen close to the planet's southern limb. Between the southern edge of Syrtis Major and the southern polar cap is the giant Hellas Basin.

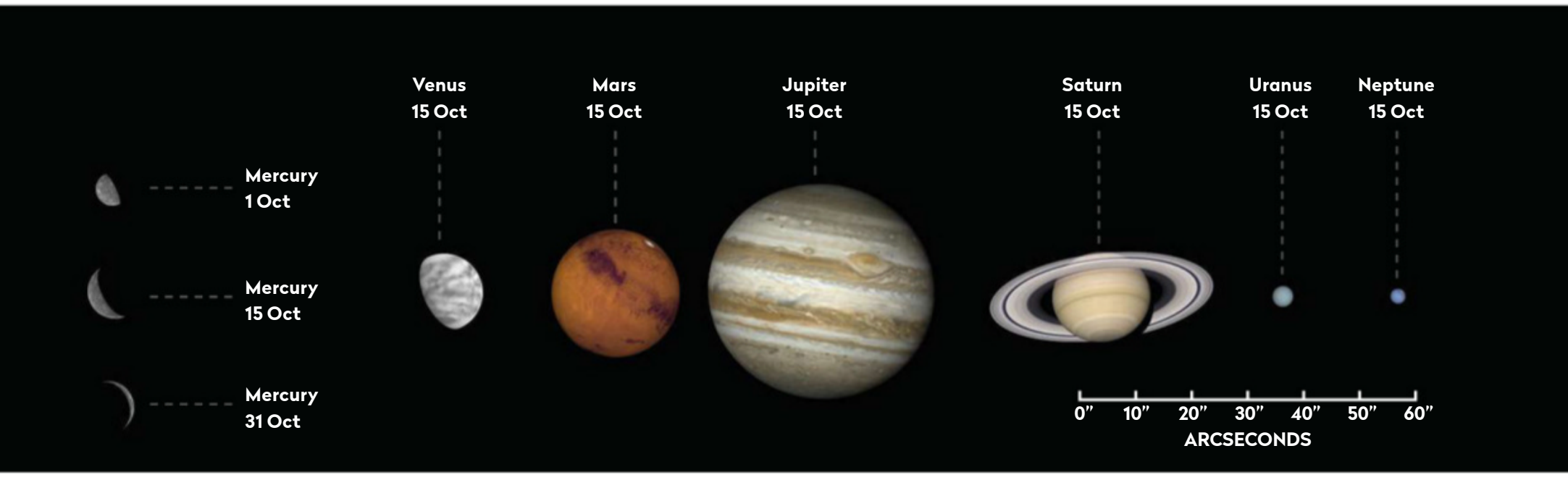

▲ Mars is closest to Earth on 6 October, presenting a disc 22.6 arcseconds across

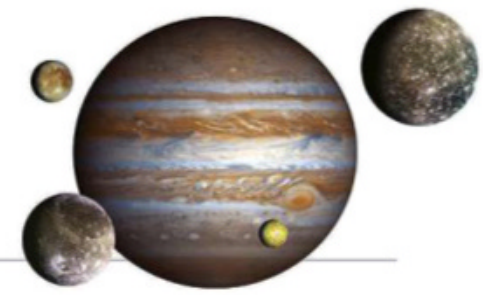
PETE LAWRENCE X 3

At the start of October, Mars shines at mag. –2.5 and appears 22.5 arcseconds across. At closest approach on 6 October, Mars will shine at mag –2.6 as it reaches its maximum apparent diameter of 22.6 arcseconds. By opposition on 13 October, it remains at mag. –2.6, but will have shrunk to 22.4 arcseconds. By the end of the month, the magnitude will have decreased to –2.2 and the apparent size to 20.2 arcseconds.

The planets in October

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Mercury

Mercury reaches greatest eastern elongation (25.8°) on 1 October when it should theoretically be visible in the evening twilight, but its position is poor and it's unlikely to be seen. Inferior conjunction occurs on 25 October.

Venus

Best time to see: 3 October, 05:30 BST (04:30 UT)
Altitude: 19°
Location: Leo
Direction: East

Venus is a spectacular morning planet, passing east through Leo before ending up in the Bowl of Virgo. On the 3rd, mag. –4.0 Venus appears close to mag. +1.3 Regulus (Alpha (α) Leonis), separated from the star by 12 arcminutes as they both rise above the east-northeast horizon at 03:20 BST (02:20 UT). At the start of October it rises four hours before the Sun; a scope will reveal its phase, which is 71%-lit, increasing to 81% at the month's close.

The Moon makes its monthly visit to Venus on the morning of the 14th, when a 9%-lit waning crescent can be seen 4° to its northwest. On the morning of the 28th, when Venus has crossed over into Virgo, it passes 48 arcminutes to the north of Zavijava (Beta (β) Virginis).

Jupiter

Best time to see: 1 October, 20:00 BST (19:00 UT)
Altitude: 14°
Location: Sagittarius
Direction: South

Jupiter hangs in there this month, aided by the longer nights. At the month's start, the mag. –2.2 planet appears towards the south as the evening twilight darkens. Although the sky appears brighter towards the end of the month when Jupiter is close to its highest point due south, the difference isn't that great thanks to the expansion of the night-time period. A crescent Moon lies 3° south of Jupiter on the evening of the 22nd.

Saturn

Best time to see: 1 October 20:00 BST (19:00 UT)
Altitude: 16°
Location: Sagittarius
Direction: South

Saturn currently appears close to Jupiter in the sky, 7.4° east and slightly north of it on the 1st, and 5.2° east and slightly north on the 31st. Saturn shines with an off-white colouration at mag. +0.8 on the 1st, dimming to +0.9 by the 31st. Its rings are tilted by around 22.6° with the north pole tilted towards Earth.

Uranus

Best time to see: 31 October
Altitude: 51°
Location: Aries
Direction: South

Uranus reaches opposition on the 31st. Currently located within Aries, the green hued planet shines at mag. +5.7 and is, theoretically, visible to the naked eye. Located in southern Aries, it can take some finding with binoculars. It's located roughly halfway between Hamal (Alpha (α) Arietis) and Kaffaljidhma (Gamma (γ) Ceti).

Neptune

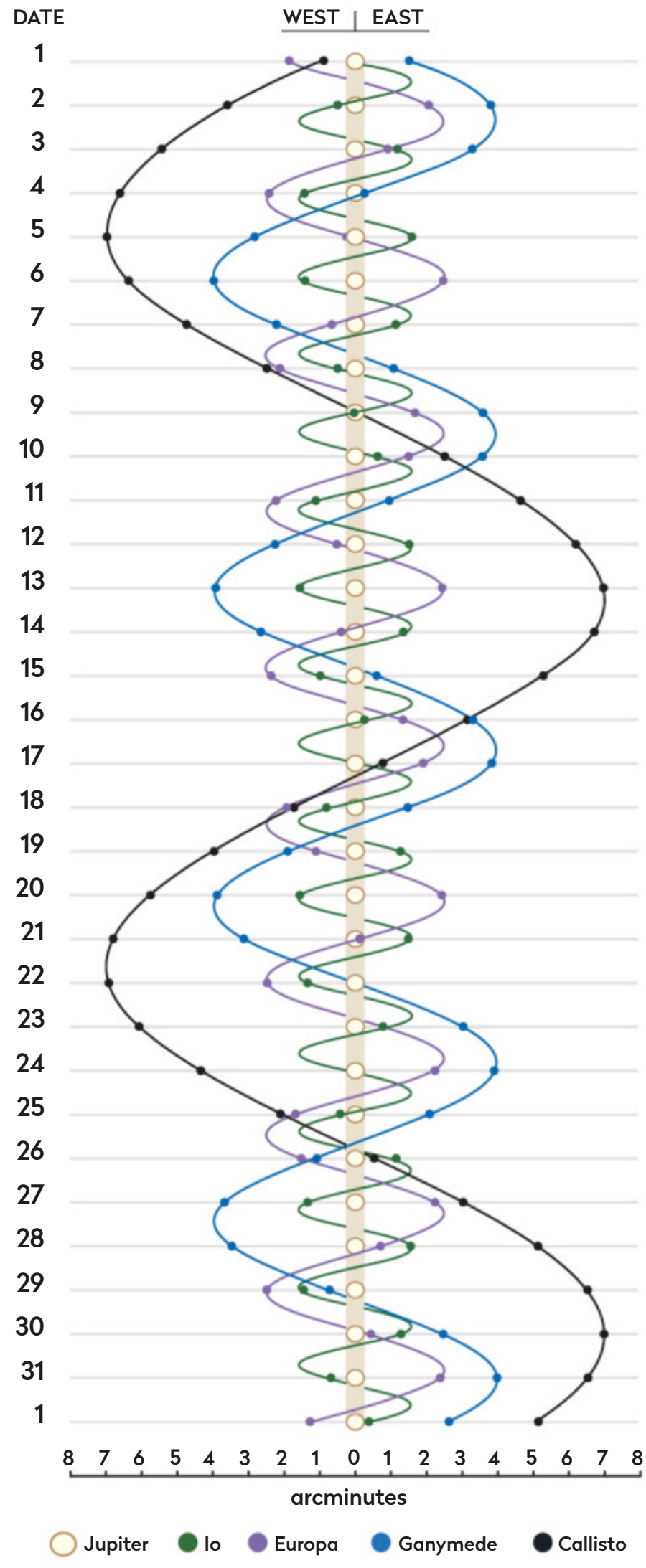
Best time to see: 1 October, 23:50 BST (22:50 UT)
Altitude: 32°
Location: Aquarius
Direction: South

Neptune was at opposition last month and remains well placed for observation. The blue-hued planet shines at mag. +7.8, so you'll need binoculars to see it. It's located 1.5° east of mag. +4.2 star Phi (φ) Aquarii on the 1st.

More ONLINE
Print out observing forms for recording planetary events

JUPITER'S MOONS: OCTOBER

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – OCTOBER

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

When to use this chart

1 October at 01:00 BST
15 October at 00:00 BST
31 October at 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.

Sunrise/sunset in October*

Date	Sunrise	Sunset
1 Oct 2020	07:12 BST	18:46 BST
11 Oct 2020	07:30 BST	18:22 BST
21 Oct 2020	07:49 BST	18:00 BST
31 Oct 2020	07:08 UT	16:39 UT

Moonrise in October*

Moonrise times

1 Oct 2020, 19:11 BST	17 Oct 2020, 08:14 BST
5 Oct 2020, 20:09 BST	21 Oct 2020, 13:57 BST
9 Oct 2020, 22:32 BST	25 Oct 2020, 15:34 UT
13 Oct 2020, 02:15 BST	29 Oct 2020, 16:32 UT

*Times correct for the centre of the UK

Lunar phases in October

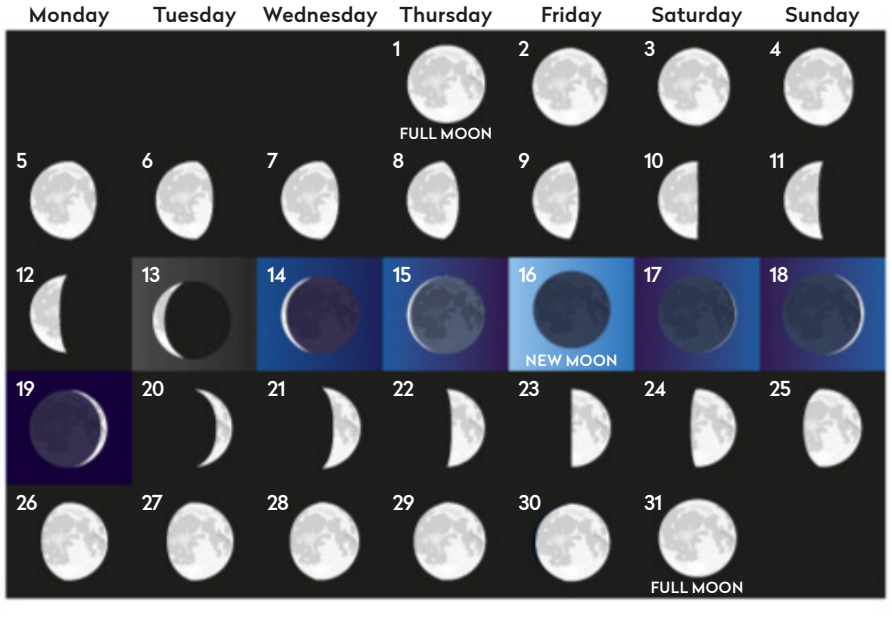
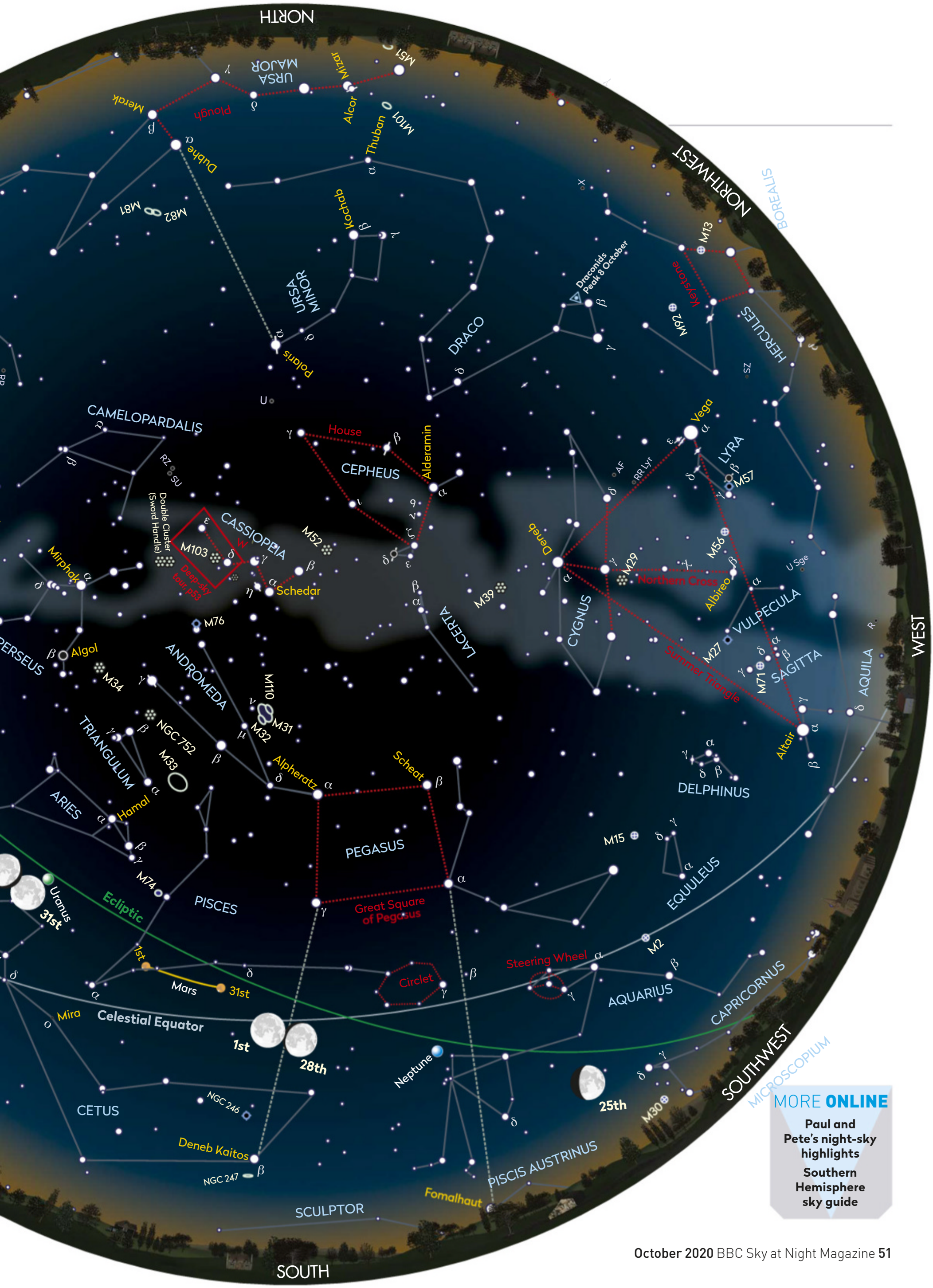


CHART: PETE LAWRENCE



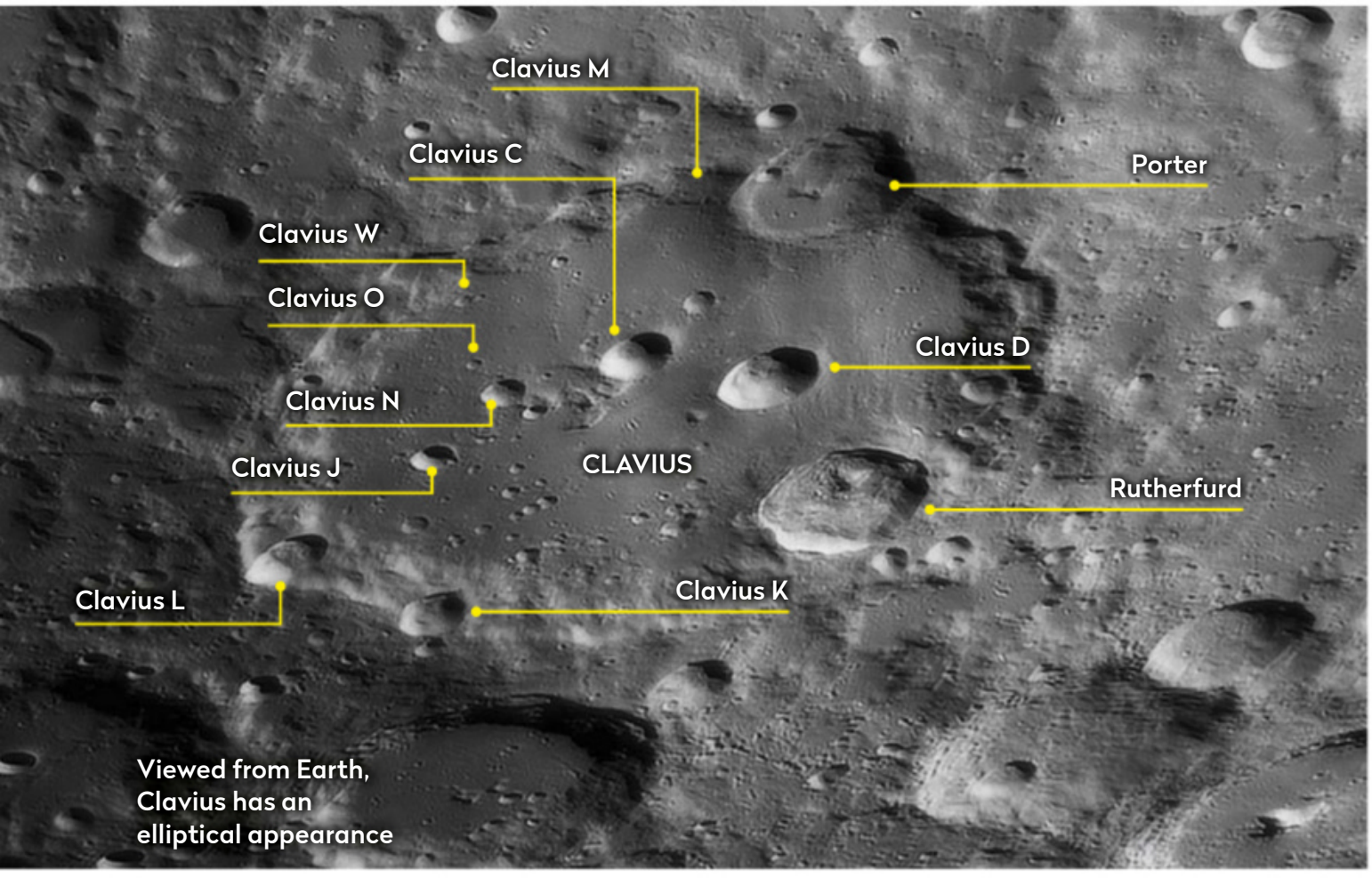
MORE **ONLINE**

Paul and Pete's night-sky highlights

Southern Hemisphere sky guide

MOONWATCH

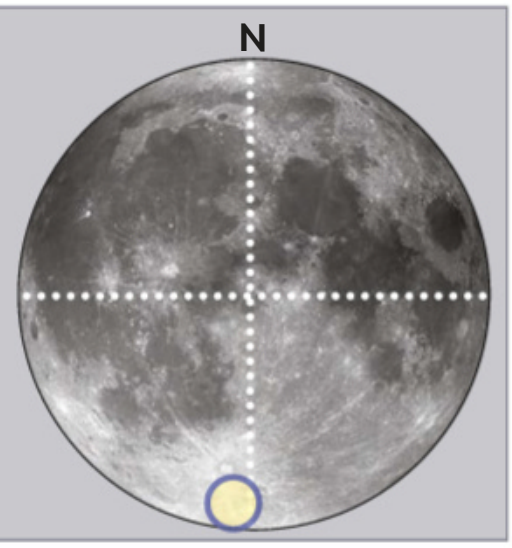
October's top lunar feature to observe



Viewed from Earth, Clavius has an elliptical appearance

Clavius

Type: Crater
Size: 225km
Longitude/latitude: 14.7° W, 58.6° S
Age: 3.9 billion years
Best time to see: One day after first quarter (25–26 October) and last quarter (9–10 October)
Minimum equipment: 10x binoculars



Located deep in the southern lunar highlands, few lunar craters are as majestically commanding as mighty **Clavius**. It's a familiar feature because of its size, characteristic appearance and because it's prominently on view between the first and last quarter phases. The start of this phase period is popular because it represents a time when viewing can be done at a relatively civilised time in the evening.

The crater is massive, with a diameter of 225km. For comparison, this makes its diameter roughly equivalent to the straight line distance between Cardiff and Manchester. From Earth, Clavius has an elliptical appearance, which is a direct result of its southerly lunar latitude. The elliptical shape is due to an effect called foreshortening; if we were able to hover directly over it, Clavius would look more-or-less circular.

For such an old feature in such a heavily cratered part of the Moon, Clavius holds its appearance well. Its rim edges are rugged but well-defined all the way round. One possible relaxation to this may be seen just to the west of 53km **Porter**, which rudely interrupts Clavius's rim along the northeastern section. The rim-line just to the west of Porter, appears to have been smoothed out. This is due to the extremely battered 44km crater **Clavius M**, almost completely disguised, sitting immediately next to Porter.

Head directly south of Porter to the southeast section of Clavius's rim and here you'll find another interruption caused by 55km **Rutherfurd**. It's interesting to compare the appearance of Porter and Rutherfurd. Although they are similar in size, Rutherfurd's floor is rugged and cracked, while Porter's is smooth with a neatly placed central mountain complex. Rutherfurd also has a central mountain, but it's displaced towards the northeast. An interesting pattern of ejecta 'furrows' appears to pass north and northwest of Rutherfurd. These, the offset mountain, and the fact that Rutherfurd's actual shape (if foreshortening was removed) is elongated north to south, suggests the crater was formed by a low angle impact from the south or southeast.

Rutherfurd marks the starting point of an impressive arc of ever decreasing craterlets. Immediately north of Rutherfurd is 28km **Clavius D** an easy target for a small telescope. Continue northwest to 21km **Clavius C**. A small scope shouldn't have any problems here either. Continue west to 13km **Clavius N**, which requires at least 100mm of aperture to see clearly. To the southwest of N is 12km **Clavius J**, again a good target for a 100mm scope.

Clavius's diameter is roughly equivalent to a straight line between Cardiff and Manchester

If you want to test your telescope's resolving power, head back to **Clavius N** and look north to a point just inside Clavius's rim. Here lies 6km **Clavius W**, a size which starts to strain the limit of a 100mm scope. Approximately one-quarter of the way from Clavius N towards W, offset slightly west, is 4km **Clavius O** which requires a 200mm instrument to see. There are many more lumps and bumps to see on Clavius's floor, and it's an interesting exercise to see how many of those annotated in our main image can be spotted visually.

PETE LAWRENCE X 3

COMETS AND ASTEROIDS

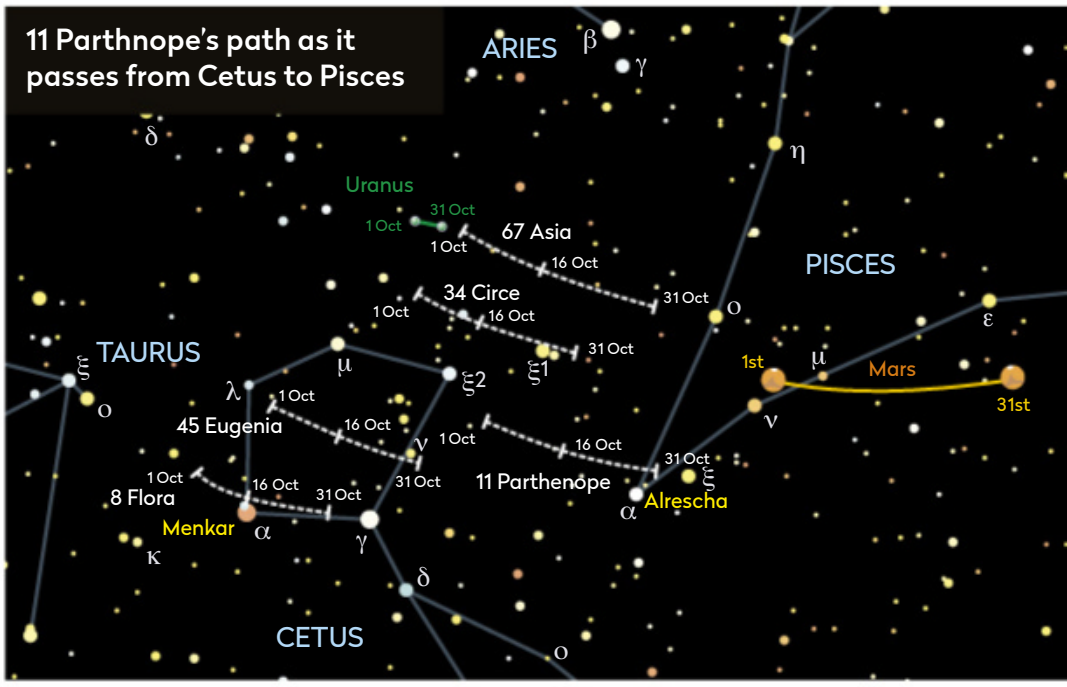
Observe minor planet 11 Parthenope reaching opposition in Pisces

Minor planet 11 Parthenope is a large body that orbits within the main asteroid belt between Mars and Jupiter. This year Parthenope has an opposition on 23 October when it will reach mag. +9.4 in Pisces. It starts the month off in Cetus, the Whale, immediately to the west of the small misshapen pentagon that represents its head. Then, during October it slowly tracks to the southwest, ending up just inside the pointed part of the portion of Pisces which is supposed to represent the rope tying two fish together.

The rope is in two parts and is 'knotted' at the star Alrescha (Alpha (α) Piscium). Parthenope's brightness varies over the month, but only slightly. On the 1st it shines at mag. +9.8, and brightens to reach a peak of mag. +9.4. By the end of the month it will have barely changed, being at mag. +9.5. This makes it an ideal target for a small scope to track. Parthenope has a diameter of 153km and during favourable oppositions can reach a peak of mag. +8.7.

This area of sky is busy at the moment; Mars is nearby, reaching opposition on the 13th, while mag. +5.7 Uranus is near too, reaching opposition on the 31st. In terms of asteroids, eighth magnitude 8 Flora, 12th magnitude 45 Eugenia and 34 Circe, together with 11th magnitude 67 Asia, will all be in the vicinity.

Parthenope is an S-type, or siliceous asteroid, a type which accounts for around 17 per cent of all known asteroids. They tend to be bright with albedos (reflectivity) around 20 per cent.



Parthenope's albedo is 18 per cent and its 3.84–year orbit takes it out as far as 2.7 AU from the Sun and in as close as 2.2 AU. It spins on its axis once every 13.7 hours. It was discovered by Annibale de Gasparis on 11 May 1850 and is named after a Greek siren who is said to have founded the city of Naples. Its name was originally suggested by John Herschel after his discovery of 10 Hygiea in 1849.

STAR OF THE MONTH

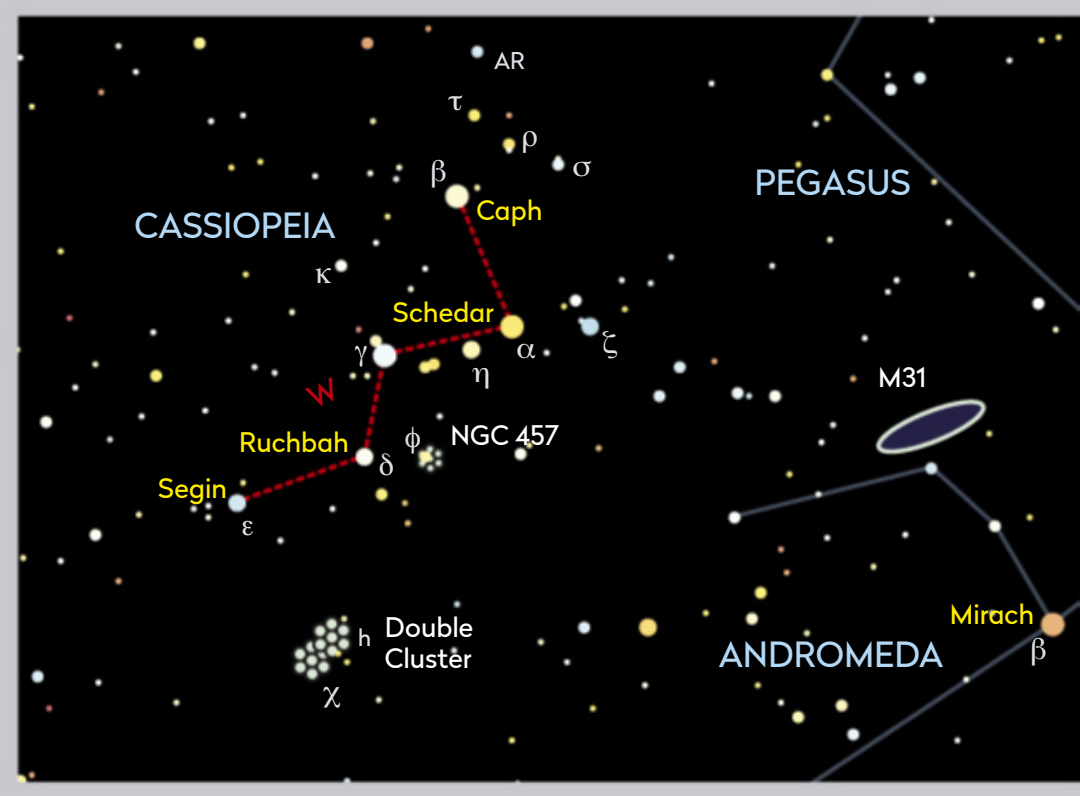
Rho Cassiopeiae, a yellow hypergiant

Rho (ρ) Cassiopeiae is a mag. +4.5 star located 2.5° southwest of Caph (beta (β) Cassiopeiae). This verging-on-dim star appears similar to the multitude of stars around it, but it is different. All of the stars we can see in the night sky belong to our Milky Way. This gravitationally bound system contains several hundred billion suns but only those in a 'bubble' around the Sun, about 10,000 lightyears in diameter with the Sun at the centre, can be seen individually with the naked eye as points of light. At 8,100 lightyears distant, Rho Cas pushes that envelope.

To appear this bright at this distance Rho Cas has to be around 550,000 times more luminous than the Sun, making it one of the most luminous stars known. As it's so distant, Rho Cas's light does battle with material along its line of sight, which is estimated to dim the star by up to two magnitudes.

Rho Cas is classified as a G2 or yellow hypergiant, with a spectral classification of G2Iae. G2 indicates it's a star of similar colour and temperature to our Sun (spectral type G2V), 'Ia' shows it's a luminous supergiant and 'e' indicates its spectrum has emission lines present.

Rho Cas is estimated to be around 450 times larger than the Sun; about 4.3 AU across. It rotates at a speed of 25km per second but being so large even at this speed, it takes it two

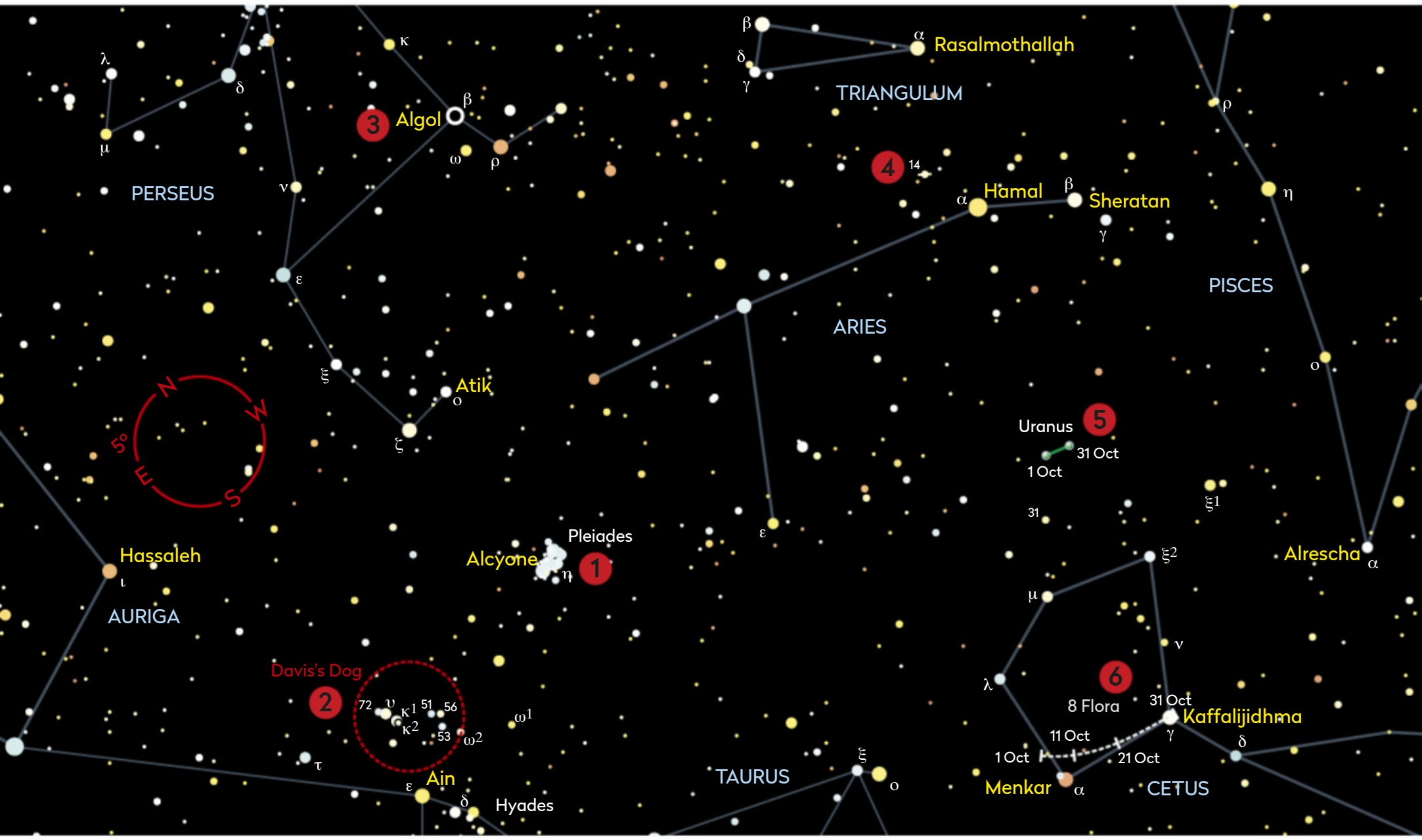


years to complete one rotation. It's classed as a semi-regular variable with an apparent magnitude range of +4.1 to +6.2. In 1946 it underwent a deep minimum, attributed to the star expelling a shell of material. This dimming seems to occur every 50 years; the last such event occurred in 2000–01.

BINOCULAR TOUR

With Steve Tonkin

The Pleiades, Uranus and Asteroid Flora are among October's wide-field highlights



1. Pleiades

10x 50 The Pleiades, also known as the Seven Sisters and M45, are easy to see with the naked-eye, even in suburban skies, but it takes binoculars to reveal the glory of this celestial delight. In the words of Tennyson, these young, hot, blue-white stars "glitter like a swarm of fireflies tangled in a silver braid". Compare the view as the evening progresses; as this lovely open cluster rises, more and more stars become visible. ☐ **SEEN IT**

2. Davis's Dog

10x 50 From the Pleiades, navigate 7.5° eastward (down) where, in a region spanning about 3.5° by 1.5°, you will find this celestial canine. Three of the brighter stars form its head, and a string of four make its tail, including the wide double star mag. +4.2 and +5.1 Kappa-1 (κ1) and Kappa-2 (κ2) Tauri. John Davis, after whom this asterism is named, sees a beagle, but I see a dachshund. What do you see? ☐ **SEEN IT**

3. Algol

10x 50 If you are new to variable star observing, Algol (Beta (β) Persei) is a good place to start at this time of year as it will be at a decent height for several months. It's an eclipsing binary star, which means that it dips in brightness when the fainter star passes in front of the brighter one. This happens every 2.85 days, when its magnitude falls from +2.1 to +3.4 for about 10 hours. ☐ **SEEN IT**

4. 14 Arietis

15x 70 Two components of this triple star, which lies 2.5° north of Hamal (Alpha (α) Arietis), are easy to see: they shine at magnitudes +5.0 and +7.9 and are separated by 108 arcseconds. The third component in this line of sight association, 96 arcseconds from the brighter star, is a bit more of a challenge at mag. +11.3; so mount your binoculars and use averted vision on a Moonless transparent night to view it. ☐ **SEEN IT**

5. Uranus

10x 50 At mag. +5.7, Uranus is theoretically naked-eye visible, but in practice this feat is unlikely under UK skies. However, even small binoculars transform it into an easy object to observe. At the month's start it lies 11° south-southeast of Hamal, 2.5° from 31 Arietis, which is a similar brightness. To be sure of your identification, observe it on several nights: Uranus is the one that moves in relation to the others. ☐ **SEEN IT**

6. Flora

15x 70 Asteroid 8 (Flora) starts October shining faintly at mag. +8.6, 1.4° north of Menkar, and ends it 0.6 magnitudes brighter, 3 arcminutes from Kaffaljidhma. The full Moon will make it difficult to see when it's close to these naked-eye stars, but you should be able to track it mid-month as it passes through the 0.5° gap between two stars of mag. +6.2 and +7.7. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 3

THE SKY GUIDE CHALLENGE

See if you can track a meeting between the two gas giants and the dwarf planet Pluto?

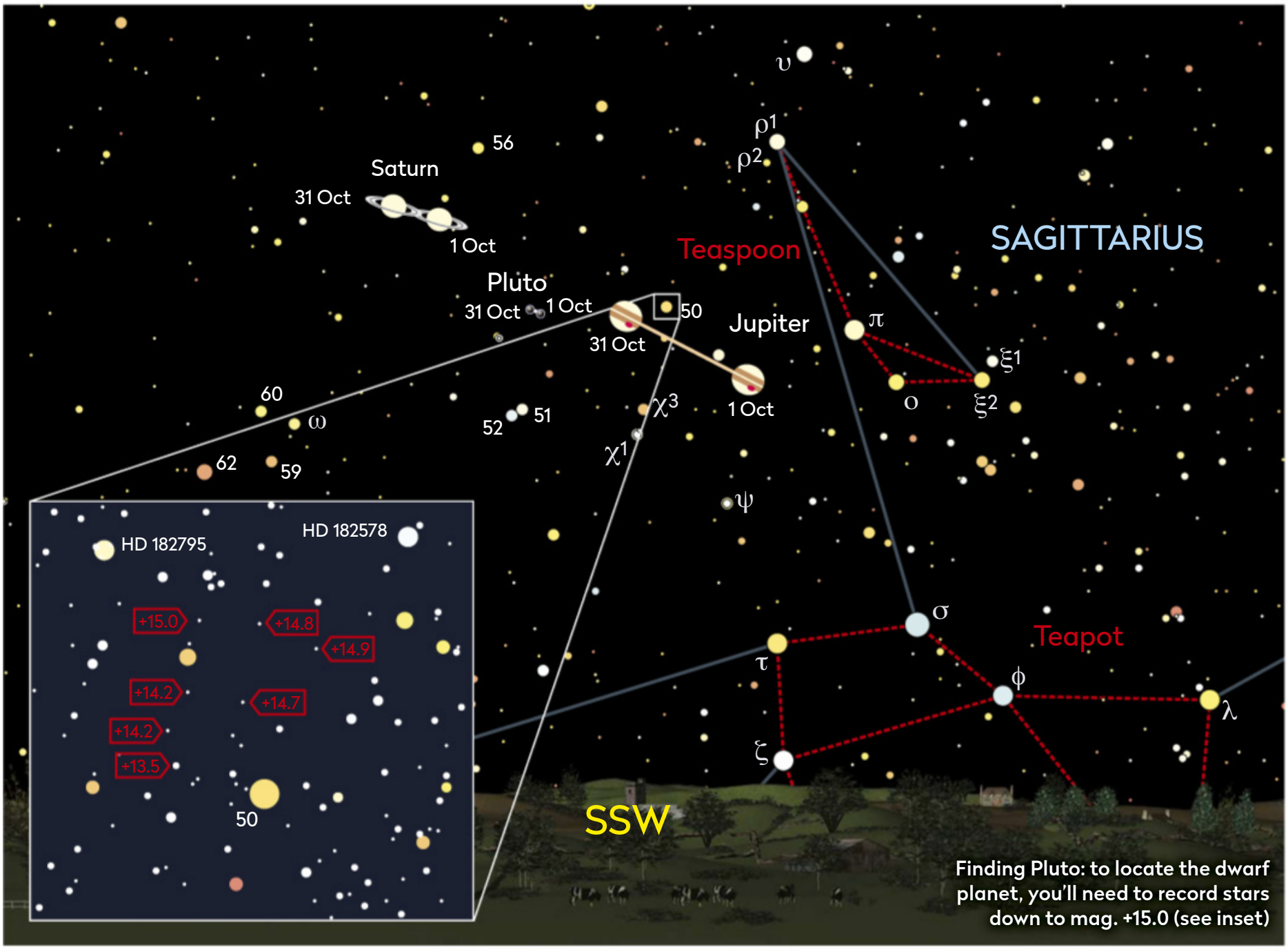
This month's challenge is to record the current meeting between bright planets Jupiter and Saturn, and the very dim dwarf planet Pluto. Where Jupiter and Saturn are easy to spot with the naked eye, to see Pluto visually requires a large aperture instrument. There are reports of it having been seen with quite modest scopes, but from the UK at least, it's rather low and affected by atmospheric haze. To be honest, even a large instrument might struggle with it currently.

Shining around 14th magnitude, Pluto does fall within range of a camera. In fact, modern imaging equipment is pretty adept at capturing objects this faint. Light pollution may cause problems, but for this challenge at least finding the dwarf planet will be straightforward: It lies just south of the line joining Jupiter and Saturn.

An equatorial tracking platform is highly recommended for this challenge; it could be a dedicated camera mount, a camera attached to a telescope on a tracking mount, or simply a camera with a standard photographic lens piggybacked onto a tracking telescope. Your setup will need to be able to record stars preferably down to mag. +15.0. The small chart (inset, below) shows stars down to this limit; we've marked several magnitudes of stars near 50 Sagittarii. In the main chart you can see the area covered by the box close to Jupiter's position on 31 October. As long as your setup can record stars close to the mag. +15.0 limit you're in with a chance of recording Pluto.

A crisp clear October night is best as well as true darkness. At the time true darkness falls the conjunction party will be low in the south-southwest. One way to confirm you've managed to record Pluto is to use images taken over several nights. Load them into a layer-based photographic editor, one image per layer, aligned using the stars, and flick between them in date order. If you've recorded Pluto, it should be visible due to its apparent motion relative to the stars.

A word of caution when using digital images to try and identify Pluto. Make sure you record a set of dark frames. These are images taken using the same camera settings as those used to image Pluto, but with the lens cap on. Average these together to reduce random noise and then subtract them from your main Pluto images. This process will eliminate hot pixels, which could be mistaken for the dwarf planet. Once you have a set of clean, hot pixel-free images, the blink method should reveal the presence of Pluto fairly easily – assuming your magnitude depth limit is low enough.



Finding Pluto: to locate the dwarf planet, you'll need to record stars down to mag. +15.0 (see inset)

DEEP-SKY TOUR

We explore the celestial highlights found in eastern Cassiopeia

1 M103

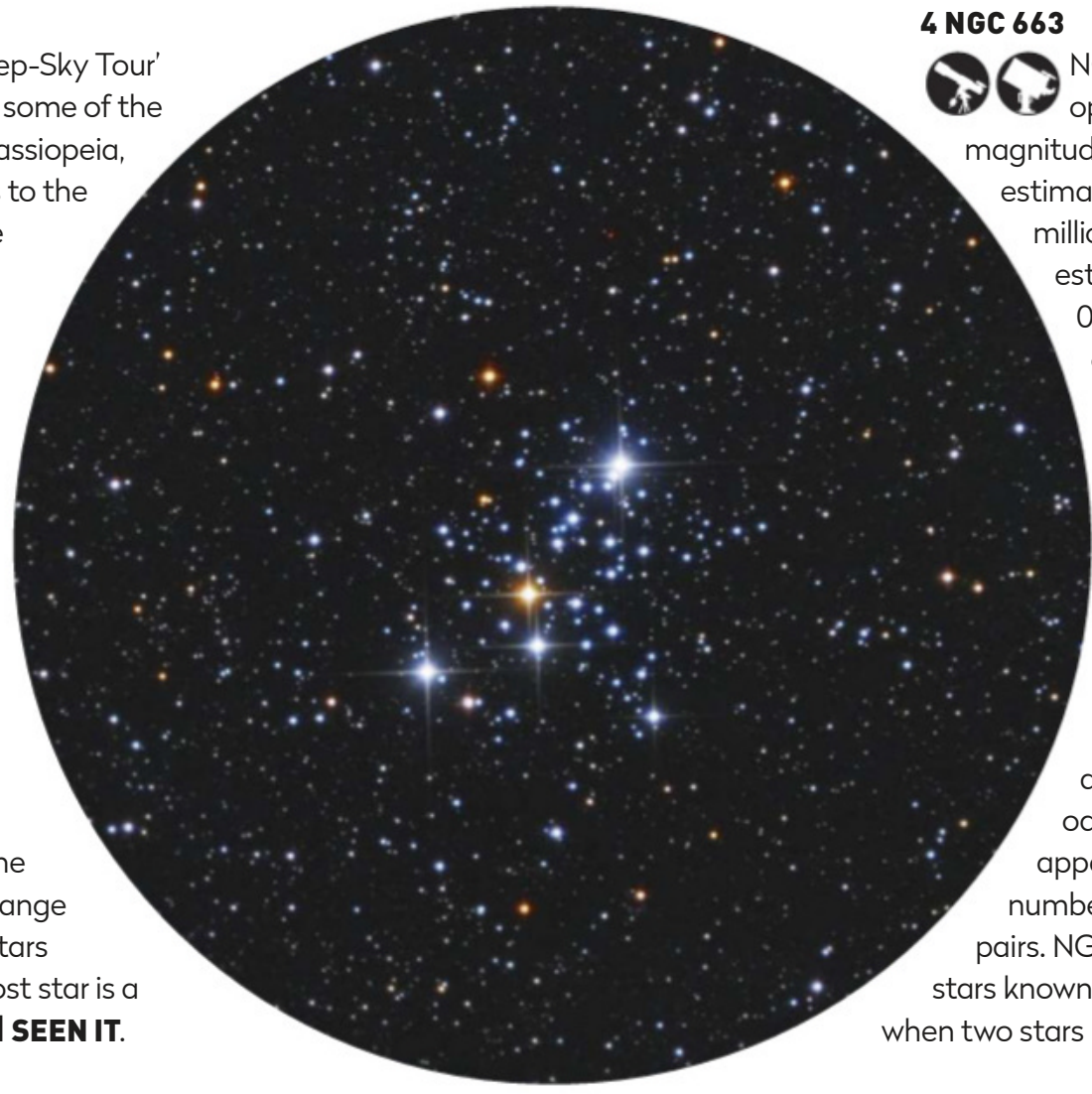
This month's 'Deep-Sky Tour' takes us through some of the wonders found in eastern Cassiopeia, a rich part of the sky thanks to the background presence of the Milky Way. M103 is an open cluster located a degree east-northeast of Ruchbah (Delta (δ) Cassiopeiae). At mag. +7.4 this is an easy find with any size instrument, but may look a bit underwhelming. The reason for this is that M103 is a sparse open cluster, 6 arcminutes in size, arranged with a triangular shape among a rich star background. Three brighter stars dominate the scene, the one in the middle looking orange compared to the two blue stars either side. The northern most star is a double named Struve 131. ☐ **SEEN IT**.

2 Trumpler 1

Open cluster Trumpler 1 is located 41 arcminutes north-northeast of M103. It's approximately 4 arcminutes in size and, at mag. +8.1, is bright enough for viewing with any instrument. Visually it appears to contain around 30 members. Four of these, around the 12th magnitude mark, are arranged in a 1.5 arcminute line, which gives Trumpler 1 a distinctive appearance. ☐ **SEEN IT**.

3 NGC 659

Centre up on M103 and drift 1.3° to the east to locate mag. +7.9 open cluster NGC 659. Alternatively, locate the mag. +5.8 star 44 Cassiopeiae and NGC 659 is located 11 arcminutes to its northeast. Despite its magnitude rating, NGC 659 is faint through most instruments. A 100mm scope at low power shows a 3 arcminute glow near to 44 Cassiopeiae, while a 250mm scope using a low power eyepiece shows it as a concentration around 3 arcminutes across, containing stars mostly around 11th to 12th magnitude. Higher power eyepieces will make the central region easier to see with larger instruments. ☐ **SEEN IT**.



MICHAEL DEGER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

▲ Get started by locating the open cluster M103, which is easy to find on any size of instrument

4 NGC 663

NGC 663 is a star-rich open cluster with a rated magnitude of +7.1. It's a young cluster, estimated to be younger than 25 million years old, and contains an estimated 400 members. It sits 0.6° north-northeast of NGC 659 and appears a quarter of a degree across through a 150mm scope, an aperture size which reveals around 30 of the cluster's 400 members. A 250mm instrument will show twice that number, the cluster's outer boundary also appearing larger at 20 arcminutes. One odd characteristic of its appearance is the presence of a number of similar brightness star pairs. NGC 663 contains at least five stars known as 'blue stragglers'; formed when two stars merge together. ☐ **SEEN IT**.

5 NGC 654

Located 40 arcminutes to the north-northwest of NGC 663 lies our next target, another open cluster called NGC 654. Marginally brighter and larger than NGC 659, at mag. +6.5, it has a full apparent size of 8 arcminutes. Small instruments will see the cluster as a smaller object around the 3-4 arcminute range. The age range of NGC 654 is between 15-40 million years. A 250mm instrument will show NGC 654 to be approximately circular with around 20 stars visible in a 3 arcminute region. A 300mm scope improves on these statistics, expanding the member count by 50 per cent to around 30 stars in an area a bit under 5 arcminutes across. The brightest member is a yellow supergiant star shining at mag. +7.3. ☐ **SEEN IT**.

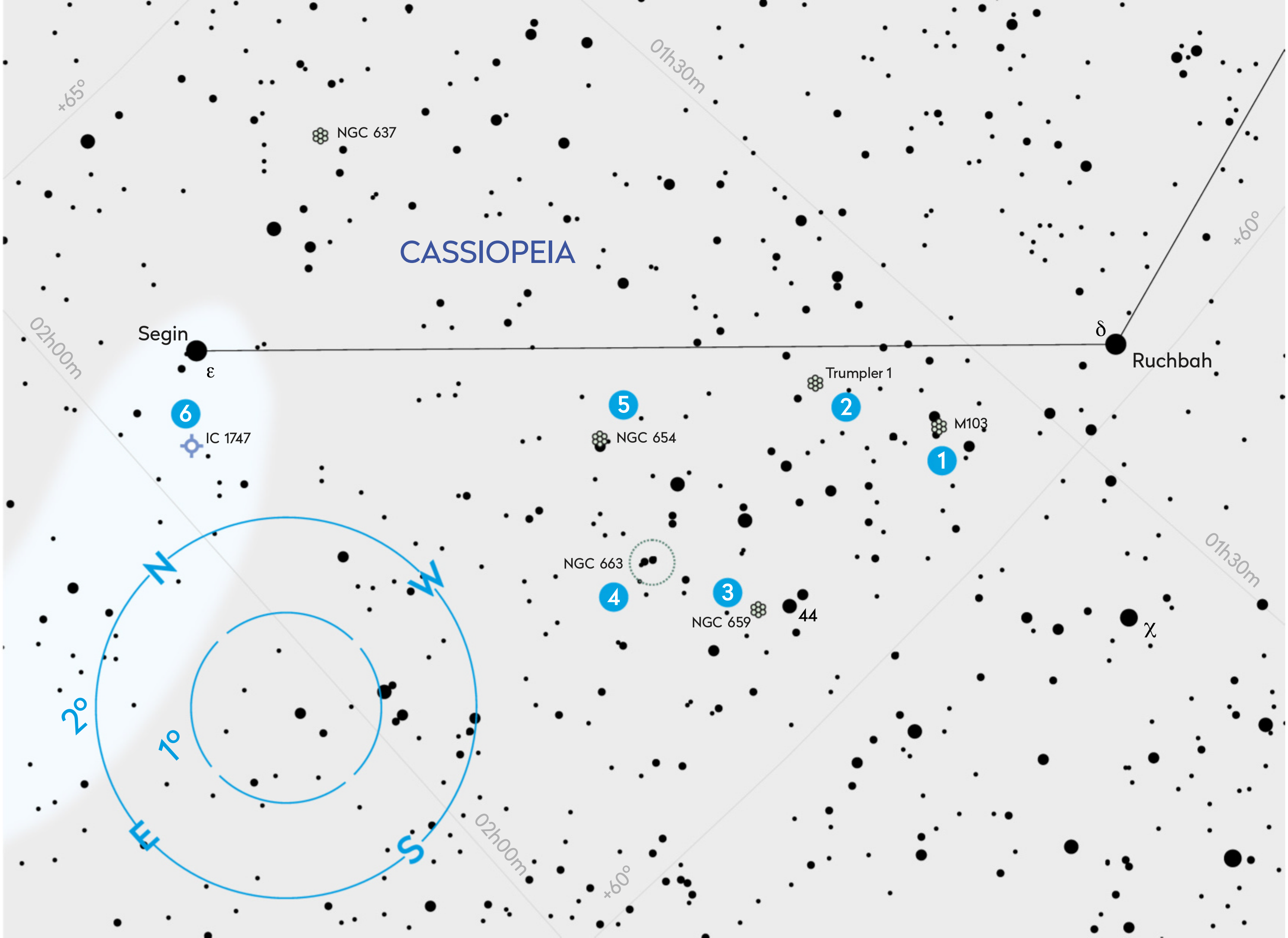
6 IC 1747

Our final target for this month's tour isn't an open cluster: IC 1747 is a 12th magnitude planetary nebula which requires larger apertures to see well. It's pretty easy to find, being located half-a-degree to the southeast of Segin (Epsilon (ε) Cassiopeiae), the star that marks the eastern end of the W-shaped constellation of Cassiopeia. The nebula is characteristic for a planetary in that it appears small at 13 arcseconds across. In its favour, it does appear quite concentrated and should be fairly evident as a planetary nebula for apertures over 250mm at magnifications of 200x or higher. An interesting line of 11th and 12th magnitude stars appears to point towards IC 1747, starting north-northeast of the object. ☐ **SEEN IT**.

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.


CASSIOPEIA
+65°
01h30m
+60°
02h00m
NGC 637
Segin
ε
δ
Ruchbah
Trumpler 1
M103
NGC 654
NGC 663
NGC 659
44
χ
1
2
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6
IC 1747
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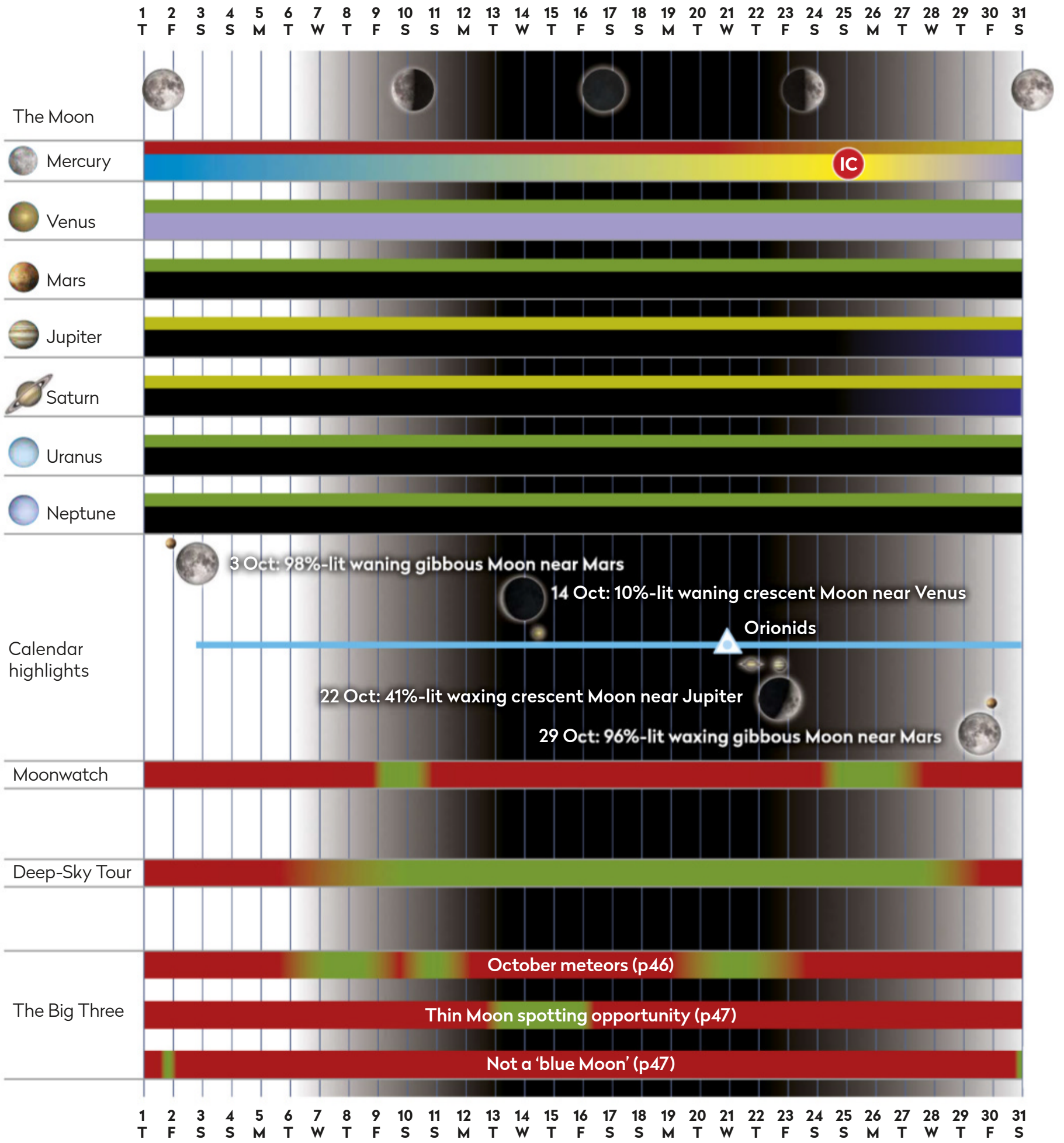
1°

AT A GLANCE

How the Sky Guide events will appear in October



KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

IC Inferior conjunction (Mercury & Venus only)

SC Superior conjunction

OP Planet at opposition

Meteor radiant peak

Planets in conjunction

Full Moon

First quarter

Last quarter

New Moon

CHART BY PETE LAWRENCE

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#astrophoto2020

Self-portrait under the Milky Way © Evan McKay

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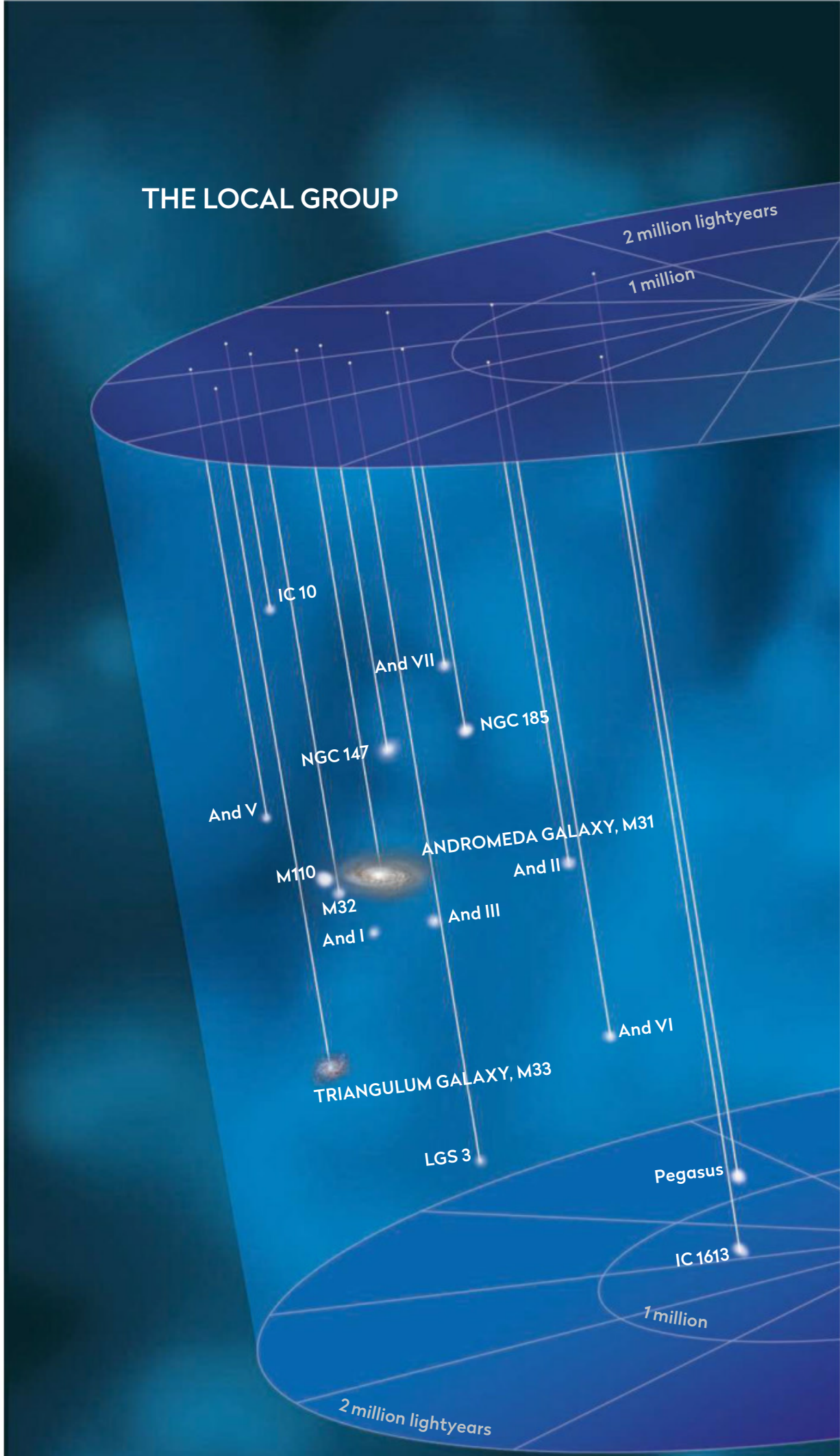
NEIGHBOURHOOD WATCH

A tour of our local galactic group

Autumn skies in the Northern Hemisphere bring many of the Milky Way's nearby galaxies into view. **Paul Money** takes an observing tour of them

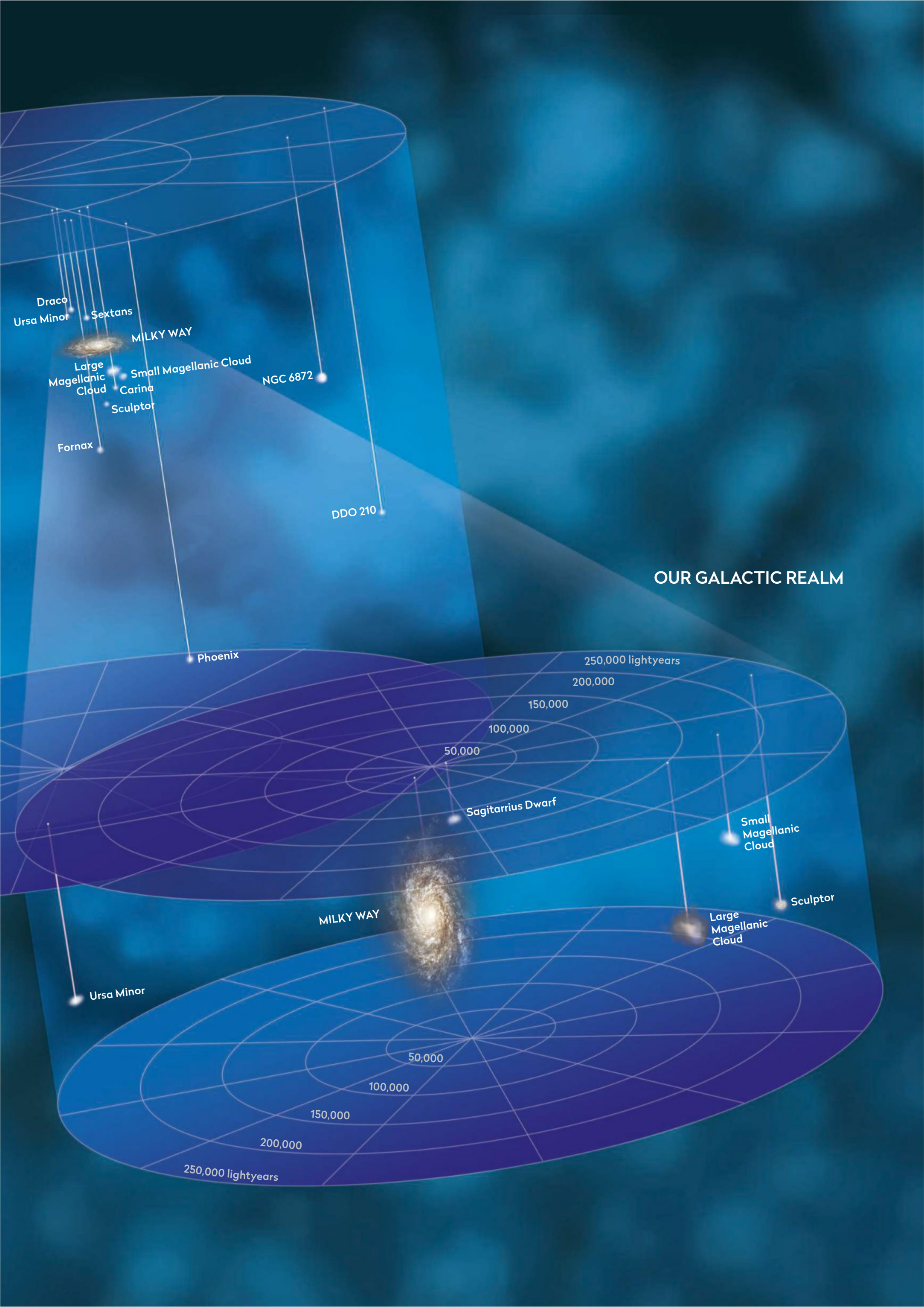
We used to think we lived in an 'island universe' consisting only of our Milky Way. However, many of the faint smudges once called nebulae turned out to be other 'island universes' too, our view of the Universe being fundamentally altered in 1924 when Edwin Hubble proved they were galaxies much like our own. As time went by, we found these galaxies liked to form groups and it was quickly observed that we were part of one, which was imaginatively named the 'Local Group'.

Our galactic neighbourhood includes two spiral galaxies (the Andromeda Galaxy, M31, and the Triangulum Galaxy, M33); two satellites of our Milky Way (the Large and Small Magellanic Clouds); the companion galaxies to M31; and several outlying galaxies (NGC 185 and 147), along with dozens of dwarf galaxies too faint for us to view. From the Northern Hemisphere at this time of year, several of the major members of our Local Group can be seen in the autumn night sky, so let's go on an extragalactic tour to see those that are accessible with modest equipment. ▸

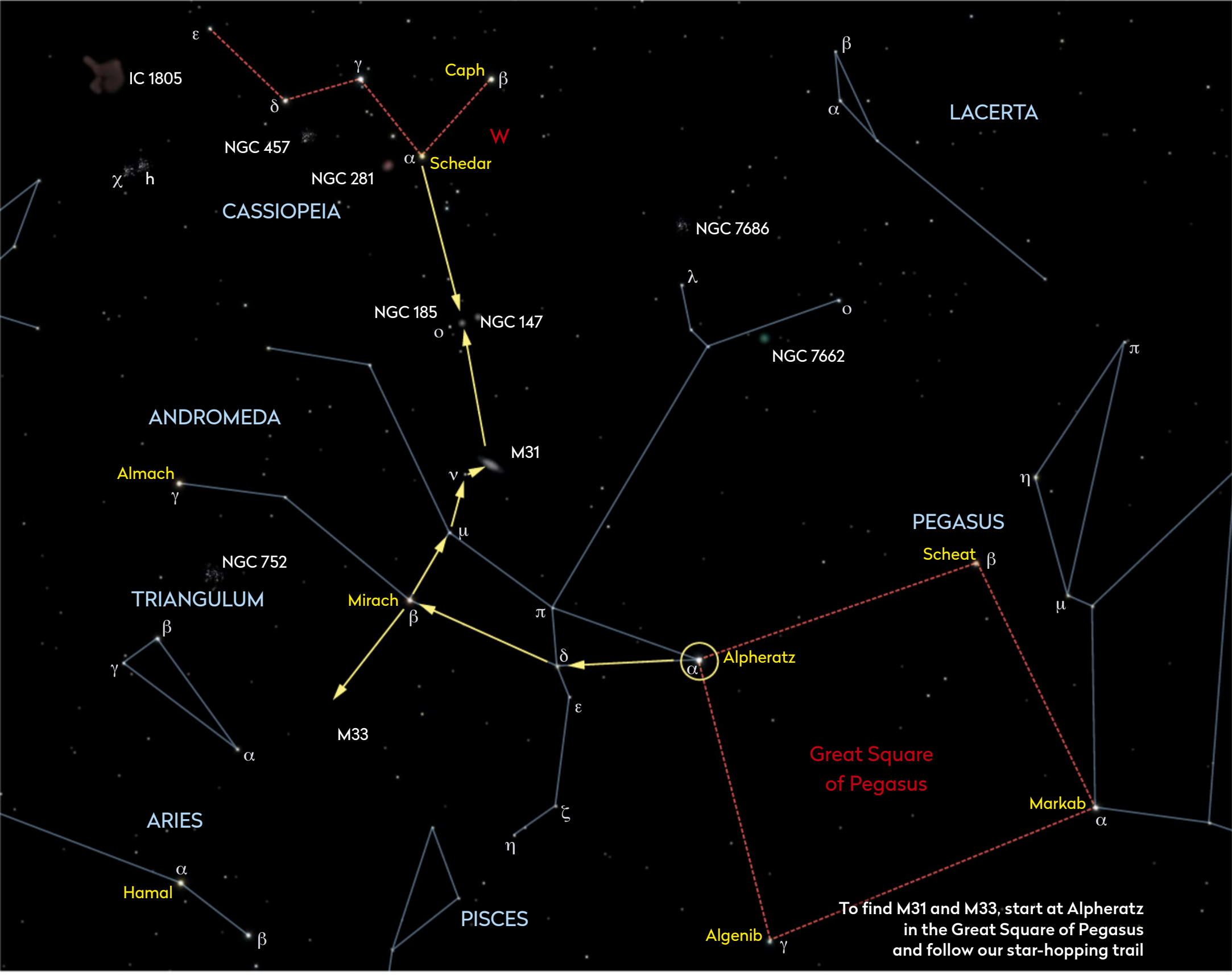


Welcome to the neighbourhood:
Stretching across 4 million lightyears, most of the galaxies in the Local Group (top) are dwarfs, but the two largest, M31 and our own Milky Way (bottom), are giant spirals. Our tour takes you around the visible members

ILLUSTRATION: PAUL WOOTTON: ORIGINAL CREATION BY DAVID RUMSEY/NATIONAL GEOGRAPHIC SOCIETY (U.S.); WWW.DAVIDRUMSEY.COM



OUR GALACTIC REALM



▸ We start with perhaps the most famous of them all, the **Andromeda Galaxy, M31**. To find it, begin by locating the Great Square of Pegasus (see chart above) and its top, left-hand bright star Alpheratz, or Alpha (α) Andromedae (which used to be designated Delta (δ) Pegasi). Move a little to the left to find Delta (δ) Andromedae and then continue left to the next bright, orange-looking star, which is Mirach, or Beta (β) Andromedae. Next, we take a sharp right turn up to Mu (μ) Andromedae and move a little further on to Nu (ν) Andromedae. Here, just to one side of Nu is a hazy, naked-eye patch of light – the core of the Andromeda Galaxy.

Let there be light

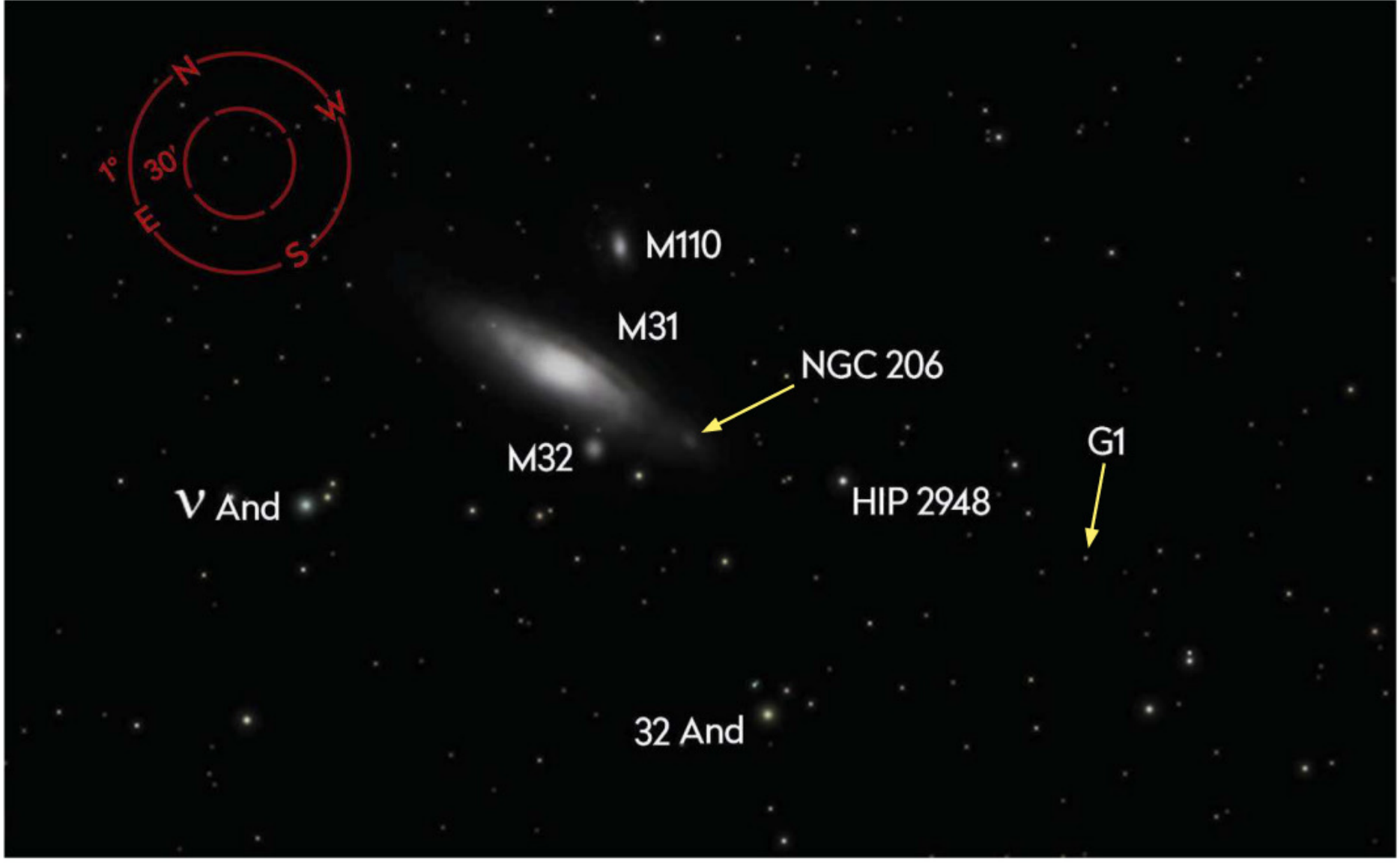
Take in M31's patch of light with the naked eye. Often regarded as the furthest you can see with your eyes on a dark, moonless night, it takes an estimated 2.5 million years for the light from the Andromeda Galaxy to reach our eyes, so don't blink! Some records suggest it may have been noted as a little cloud by Persian astronomers as early as AD 905, while Charles Messier added it to his famous catalogue in 1764.

▼ In a dark sky, the Andromeda Galaxy, M31, can often be seen with the naked eye; averted vision is recommended

When viewing M31, try using averted vision – the art of looking slightly to its side. This will bring out fainter detail and more of an extended haze either side of the core, which is some of the Andromeda Galaxy's disc. Binoculars or a telescope will bring out even more of this hazy disc, and maybe hints of a spiral arm. This nearer arm is more sharply defined due to lanes of dust, which are often well seen in astrophotos. In binoculars M31's disc extends 3° from one side to the other, and it stretches even further when photographed. The galaxy is tilted at about 13°, which puts its central bulge and the tightly wrapped spiral arms nicely on view. It is amazing to think that M31 may contain over a trillion stars, according to data from the Spitzer Space Telescope, making it much larger than our own Milky Way.

Binoculars mounted on a tripod for stability should show there are two companions to the Andromeda Galaxy – M32 and M110 – roughly either side of the central bulge. **M32** lies close to the apparent edge of the bulge, but careful observation may just make out that the faint part of the bulge can extend past it. M32 is an elliptical galaxy with

PETE LAWRENCE X 5, DAVIDHAJNAL/ISTOCK/GETTY IMAGES



little in the way of gas and dust left, literally just a mass of stars, glowing at mag. +8.1 with its major axis pointed roughly towards the centre of the Andromeda Galaxy. It makes a triangle with two ninth magnitude stars and there is a seventh magnitude star nearby too, which helps locate it. Across from M32, past the Andromeda Galaxy's central bulge, we find **M110**. This is another elliptical galaxy, shining at mag. +8.5, but it's slightly larger than M32 and appears a little fainter because of its diffuse nature. Both galaxies are gravitationally tied and effectively in orbit around the Andromeda Galaxy, so you could say we are seeing three galaxies for the price of one when we view it.

▲ Local highlights: search around the Andromeda Galaxy, M31, to observe galaxies M32 and M110, plus the star cloud NGC 206 and globular cluster G1

M31 has a few more tricks up its sleeve. With a telescope you can bring out further detail, such as its dust lanes and also a star cloud, **NGC 206**, of which there are similar objects in our own Milky Way, like M24, the Sagittarius Star Cloud. NGC 206 does require medium to large telescopes to bring out its nature visually, and it can be photographed with wide, ▸

Viewing the Local Group

What different instruments will show you of our neighbouring galaxies

Our Local Group tour can begin with the naked eye which, depending on how dark your sky is, can show M31 and possibly M33. A humble pair of binoculars – 7x50s to 15x70s – will reveal the galactic disc of M31, show M33 as a hazy glow and bring out M31's two primary companions.

A wide-field telescope will improve the discs of both galaxies and make the dust lanes of M31 apparent. We used a 100mm spotting scope to track down the galaxies NGC 185 and the fainter smudge of NGC 147. Larger scopes – 10-inch reflectors and above – will make short work of these two, but won't reveal more detail.

Turning such scopes on M33 reveals some of its nebulae, like NGC 604. With a 10-inch reflector, M31's disc begins to reveal similar features, like star cloud NGC 206, with more defined edges to its dust lanes.

The latest high-tech scopes will take you deeper. With live-stacked images in its electronic eyepiece, Unistellar's eVscope can show fainter objects and colour in many of them. Stacking images live via software can also bring more of these Local Group objects into view for public outreach events. Alternatively, the OVNI-M Series Night Vision Eyepiece uses phosphorous to intensify the view through any scope.

▲ Simulated views of the Triangulum Galaxy, M33, with (from left) the naked-eye, binoculars and a small telescope

Imaging the Local Group

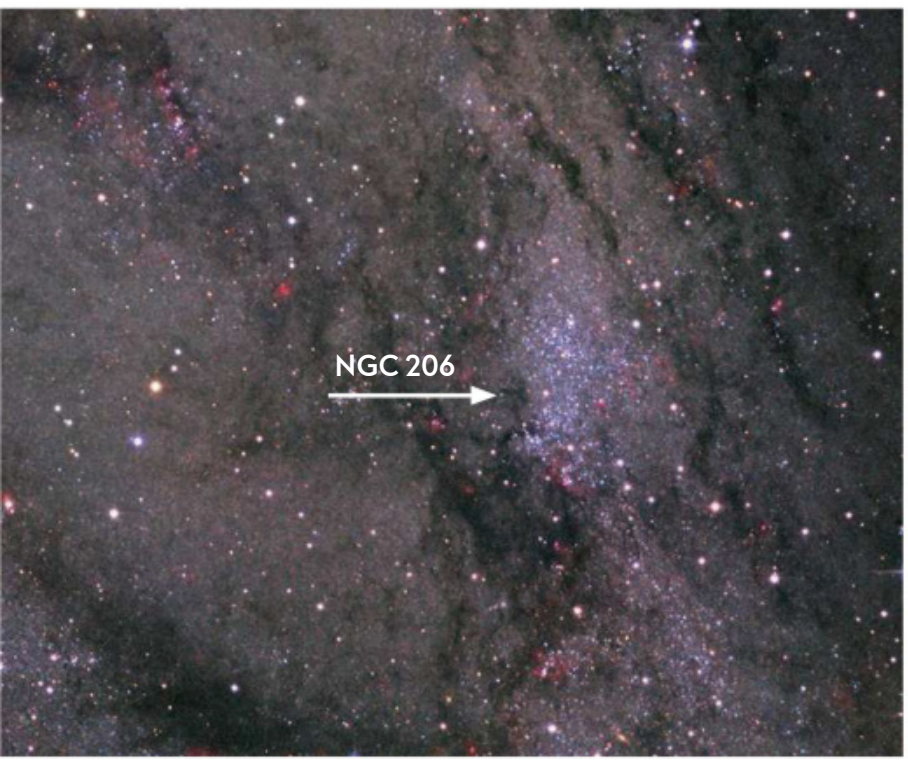
How to capture our nearby 'island universes'

We live in amazing times, where smartphones can take images of the constellations and pick up both the Andromeda and Triangulum Galaxies in the Northern Hemisphere, and the Magellanic Clouds in the Southern Hemisphere. Moving up to DSLRs, with a wide-field lens and a high ISO capability, you'll also be able to image them, especially when fitted to a portable tracking mount. By adding shorter focal-length lenses, the two companions of M31 can also be captured, along with the disc of the Andromeda Galaxy.

Even more detail can be imaged with an equatorial mount as a platform, either by taking long, guided exposures or by stacking lots of short exposures through a telescope. This will capture the dust lanes of the Andromeda Galaxy, NGC 185 and NGC 147, and some of the nebulous parts of the Triangulum Galaxy such as NGC 604. Increasing the aperture of your telescope and using a deep-sky CMOS or CCD camera will add even more detail and allow you to image the globular clusters of the Andromeda Galaxy too.

By using either an automated remote imaging setup or the Stellina imaging system (right), it's now possible to capture not just the popular members of the Local Group, but also many of the fainter targets.

► The Stellina Observation Station is a fully automated option for deep-sky imaging, which we reviewed in our February 2020 issue



◄ NGC 206 is a star cloud within the Andromeda Galaxy that can be resolved with larger telescopes

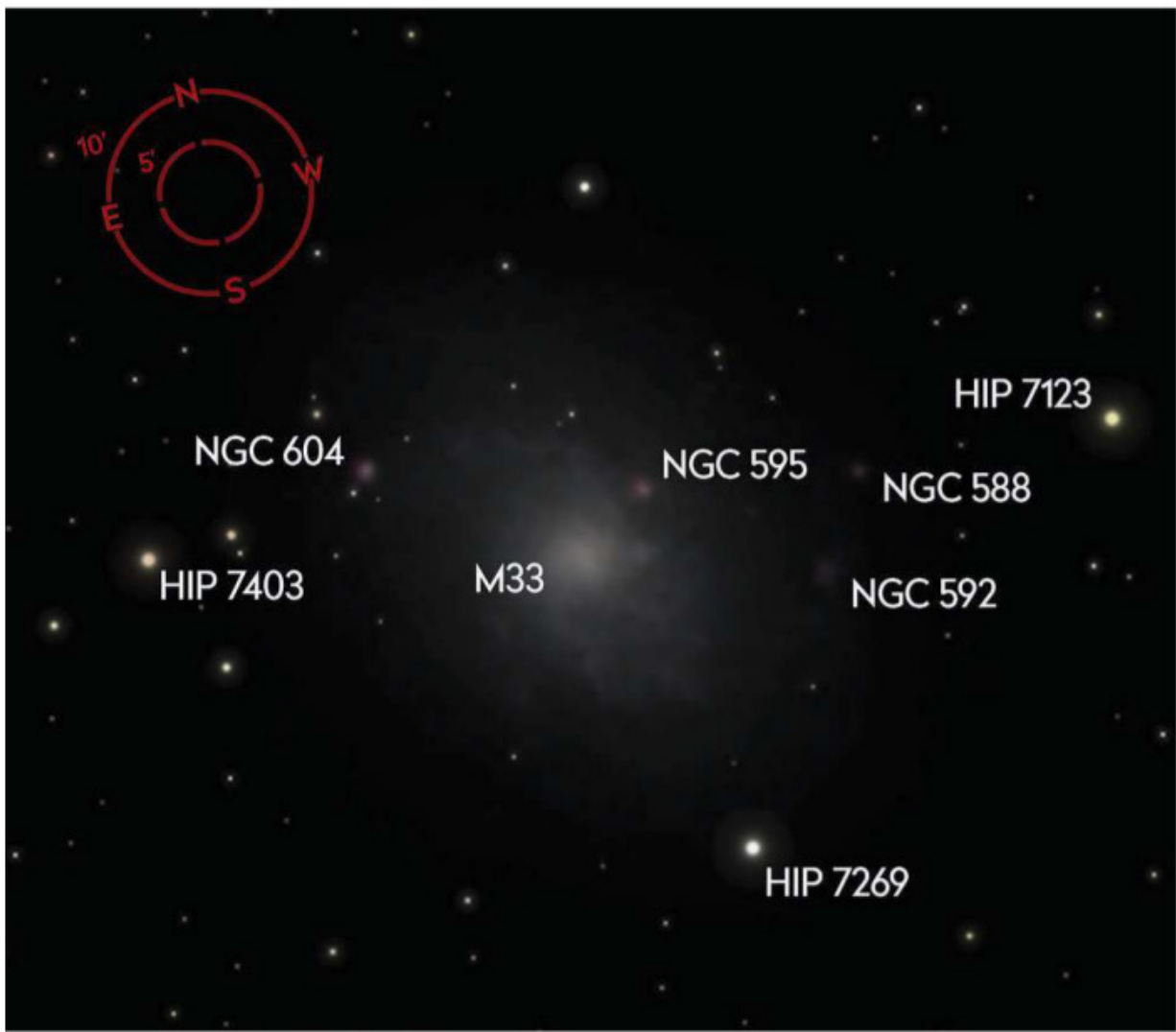
▼ Binoculars are recommended for finding the Triangulum Galaxy, while a telescope will reveal nebulae in its spiral arms, including NGC 604, 595, 592 and 588

► rich-field telescopes too. There are also the globular clusters surrounding the Andromeda Galaxy to seek out. Again, large aperture is best: the brightest, **G1** (also known as Mayall II), located 2.5° southwest of M31's centre, glows at mag. +13.81 and is best seen in 10-inch or larger telescopes.

Now, let us turn to our next Local Group target, the **Triangulum Galaxy, M33** naturally located in the Triangulum constellation. Locate it from Mirach, Beta (β) Andromedae – it's the same distance away from this star as M31, just in the opposite direction (see the star-hopping chart on p62). You're looking for a small, hazy patch. Despite technically being a naked-eye object at mag. +5.5, M33 doesn't seem to be as easy to spot as you might think, so binoculars will be useful here. It doesn't have the large, bright central bulge of M31.

This is down to the fact M33 is almost face-on to us and, without a bright central bulge, it is quite diffuse. Yet from a dark, moonless site it is possible to spot it with the naked eye if you have keen eyesight. If you do, then you have just pushed your viewing distance out to an impressive 2.73 million lightyears.

With a telescope, M33 will show a hazy patch of light that hints at a spiral shape and it contains a wonderful surprise. There is a large, gaseous nebulae located in its spiral arms, similar to the Milky Way's Orion Nebula but around 10 times larger. This is **NGC 604**, which shines at mag. +12.0 and is estimated to be 1,500 lightyears across. It takes an 8-inch telescope, or larger, to really pick it out clearly against the haze of M33's spiral disc. If you enjoy challenges, it's worth exploring M33's disc carefully to see if you



▼ See if you can locate NGC 147 (or Caldwell 17), a dwarf spheroidal galaxy in the Local Group

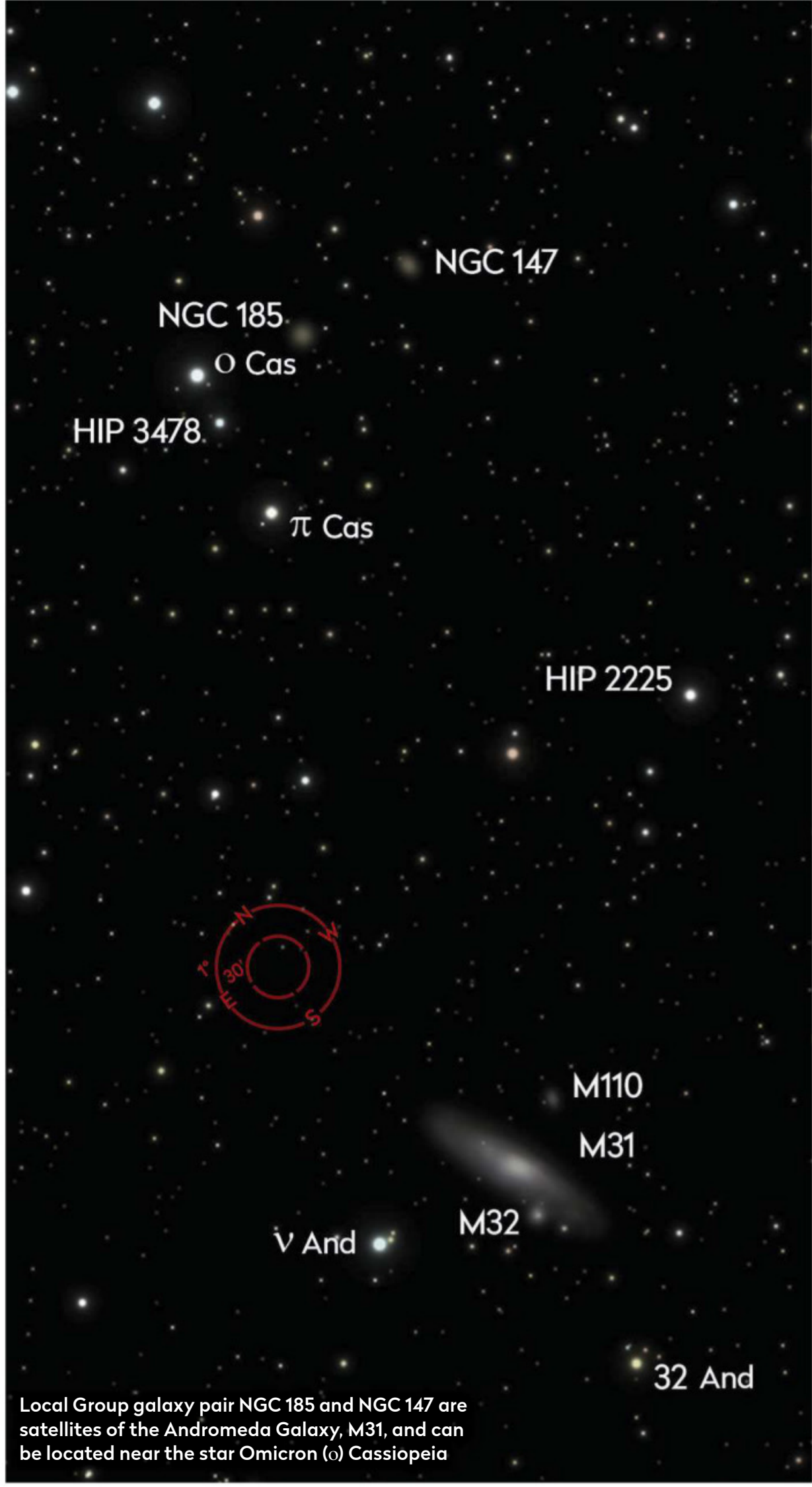
can spot other similar nebulae such as **NGC 595**, **NGC 592** and **NGC 588**, which are all fainter than NGC 604.

Around the Andromeda Galaxy

Now we're going to seek out the other two Local Group galaxies that are currently on show for Northern Hemisphere viewers, NGC 185 and NGC 147, also known as Caldwell 18 and 17 respectively. To find them, start at M31 and trace a line from there to Schedar, or Alpha (α) Cassiopeia (see star-hopping chart on p62). With at least a 6-inch reflector or a 4-inch refractor, look roughly halfway along this line for a glimpse of the brighter of the two Local Group galaxies. This is the dwarf spheroidal galaxy **NGC 185**, which is a small hazy patch of light, glowing at mag. +9.2 a degree westward of the mag. +4.5 star Omicron (ο) Cassiopeia (see chart, right). Extend the line between NGC 185 and Omicron Cassiopeia by another degree westwards to find the fainter smudge of light that is **NGC 147**. This is also a dwarf spheroidal galaxy glowing at mag. +9.7, so fainter and requiring a little more patience to pick out. Both are satellites of the Andromeda Galaxy and lie slightly closer to us at 2 to 2.5 million lightyears. Interestingly, they appear to be gravitationally connected to each other.

These are the Local Group galaxies that are visible in this part of the sky from the Northern Hemisphere. Other members include **Leo I**, a diffuse elliptical galaxy of mag. +10.4, which lies just above Regulus; and **Leo II**, a very faint diffuse galaxy at mag. +11.0, which lies above Delta (δ) Leonis. Both are in the morning sky and are satellites of our Galaxy, but they are particularly tough to spot due to their spread-out, diffuse nature.

In the Southern Hemisphere, Local Group members include the **Large** and **Small Magellanic Clouds**, which are naked-eye objects and satellites of our own Milky Way. The Andromeda Galaxy, M31, also has numerous satellite galaxies that are too faint for most backyard enthusiasts, but it's possible that imaging technology may allow them to be spotted. So stay tuned to our reviews section in case we come across suitable kit. In recent years the members of the Group have increased, with the detection of many faint dwarf and sub dwarf galaxies; at the time of writing there are an estimated 80 members, most too faint to be seen in a backyard telescope, but it is possible that our own Milky Way Galaxy's disc may hide others from view. For now, enjoy our tour of the autumn members of the Local Group and remember not to worry too much about M31 being on a collision course with the Milky Way – we have between 4 and 5 billion years before that happens!



Local Group galaxy pair NGC 185 and NGC 147 are satellites of the Andromeda Galaxy, M31, and can be located near the star Omicron (ο) Cassiopeia

Paul Money is an astronomy writer and broadcaster, and is reviews editor for *BBC Sky at Night Magazine*

THE COMET THAT CRUMBLED

Will Gater explores what happens when an icy visitor from the outer Solar System breaks apart, and what we can learn from a comet's spectacular demise

Back in the early months of 2020, a comet – formally catalogued as C/2019 Y4 (ATLAS) – was beginning to brighten as it drew ever closer to the Sun. The headlines had all the usual excitable language you'd expect, while enthusiastic social media posts spoke of possible naked-eye wonders to come. Out in the depths of space, though, the icy wanderer had other ideas. As it raced towards the Sun, astronomers started to notice ominous changes in its appearance; rather than brightening steadily as it neared perihelion in May this year – when it would be at the closest point to the Sun in its orbit – the comet's glow was faltering.

Soon, close-up images by astrophotographers showed the head of ATLAS – ordinarily where a solid, icy nucleus would hide among a shining cloud of gas and dust – was starting to elongate. The comet was falling to pieces. By 20 April, professional astronomers had pointed the orbiting eyes of the Hubble Space Telescope to the ensuing chaos, revealing fragments of the comet drifting through the darkness.

If amateur astronomers in the Northern Hemisphere felt any disappointment at what might ▸

JOHN R. FOSTER/SCIENCE PHOTO LIBRARY

An appetite for destruction: the study of a comet's disintegration can give vital clues about its construction

ILLUSTRATION

Breaking up: astronomers used the Hubble Space Telescope to image fragments of Comet ATLAS in April 2020

▸ have been, that was soon tempered by the naked-eye spectacle of Comet NEOWISE in the following months; while it graced the northern horizon with its magnificent dust tail, the fizzling away of ATLAS seemed quickly forgotten by most. Even in its death, however, ATLAS had a story to tell scientists – one not just about the fickle nature of comets, but also about the deeper history of our planetary neighbourhood.

Bright futures

Comets brighten because, as they venture close to the Sun on their long, elliptical orbits, the warmth of our star causes ices to sublimate (change straight from a solid to a gas) from their frosty surfaces. As this process unfolds, a cloud of material – known as a 'coma' (see box, opposite) – forms around the nucleus. Some comets also develop tails, giving them the striking appearance these icy objects are so well-known for.

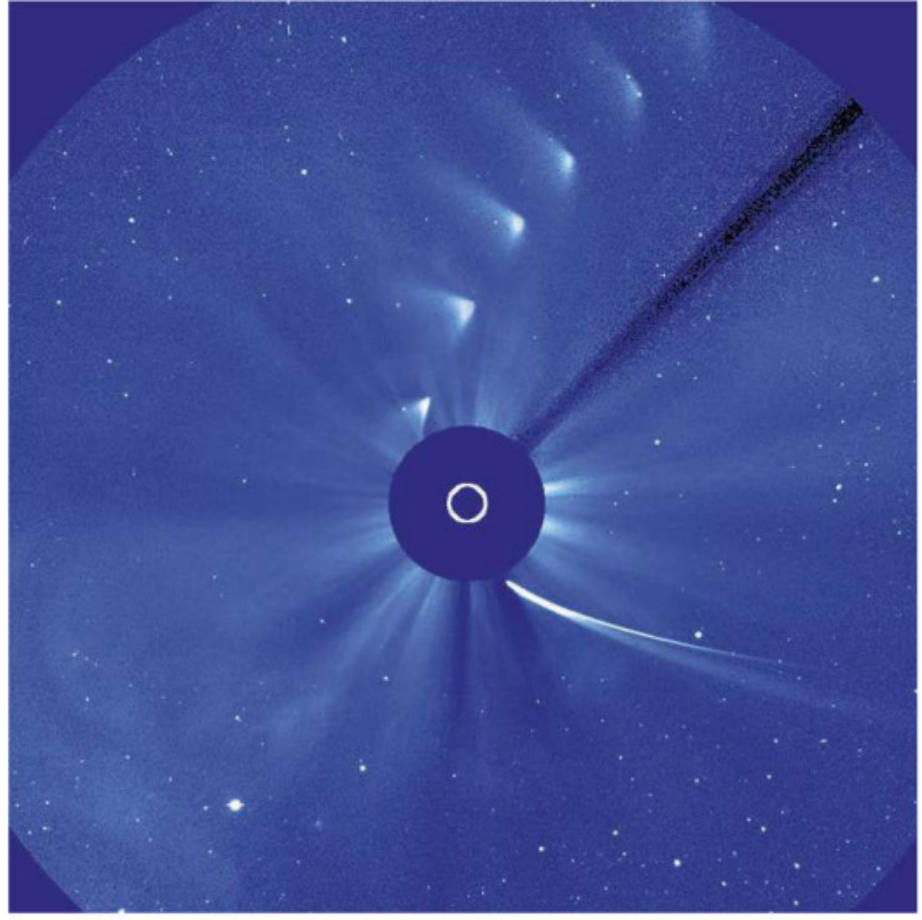
How visible and how bright a comet gets in our night sky depends on several things, such as how big its nucleus is and how close it gets to Earth and the Sun when it sweeps through the inner Solar System, explains Professor Laura Woodney, a planetary scientist and comet expert based at the California State University, San Bernardino. The age of the surface of the nucleus also plays a role. "We think that the more perihelion passages a comet has around the Sun, the more processed the surface becomes due to sublimation of ice, given that the larger rocky particles either fall back to the surface or are never lifted in the first place, forming an insulating crust over time. Thus short-period comets with their frequent solar passages are less spectacular," she says.

For certain comets making their first journey into the inner Solar System – what astronomers call a 'dynamically new' comet – the odds can be somewhat against them getting bright too. "Statistically speaking, first-time visitors that approach the Sun within 2 AU [Astronomical Units, where 1 AU is the distance between Earth and the Sun] are more likely to fizzle out. But again, outliers are not uncommon. So we don't really know," says Dr Ye Quanzhi, an asteroid and comet researcher at the University of Maryland.

▲ Historic sighting: Comet NEOWISE is captured in a stunning image during summer 2020 in the sky above Stonehenge

Anyone who remembers the saga of Comet ISON – a sungrazing comet that many hoped would become a spectacular sight in late 2013, but actually flopped – will recall the rollercoaster of emotions that comes with monitoring a dynamically new comet as it approaches perihelion. ATLAS, though, was neither a short-period comet nor dynamically new; its crumbling highlights just how hard it is, still, to anticipate the

NASA/ESA/D. JEWITT (UCLA) Q. YE (UNIVERSITY OF MARYLAND), OVERSNAP/ISTOCK/GETTY IMAGES, ESA/NASA, MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO



▲ **High hopes: Comet ISON caused disappointment to observers when it disintegrated in 2013. This image was captured by the Solar and Heliospheric Observatory (SOHO)**

behaviour of these icy travellers. Indeed, it's just one of several comets that astronomers have witnessed breaking up over the years, including Comet 73P/Schwassmann-Wachmann in 2006 and more recently Comet 332P/Ikeya-Murakami in 2015. "[Disintegration] happens regularly, both to long- and short-period comets and we aren't good at predicting why yet," says Woodney. "That's one of the interesting questions comet scientists are currently working on understanding right now." Might there have been clues from ATLAS's past, though, that pointed to its fate?

The comet caught the eye of Ye Quanzhi right from the moment it was found, back in December 2019. "The preliminary orbit closely resembled another comet that appeared almost 180 years ago, C/1844 Y1," he says. "The resemblance is a bit too great to be explained by pure coincidence, and it was pretty clear that the orbital period of ATLAS is much, much longer than 170 years. So this raised the interesting possibility that we are seeing a pair of comets that share a common progenitor and are likely to be the end-product of a prehistoric break-up event."

Help from Hubble

To explore ATLAS further, Ye and his colleagues requested time on the Hubble Space Telescope to examine the comet. "Our motivation back then was primarily to look for fragments produced during ATLAS's last visit, 6,000 years ago," he says. The team's proposal was sent to Hubble managers in January; but between then and when the orbiting telescope would actually turn its optics toward the comet, in late April, ATLAS underwent its spectacular fragmentation. ▸

Comet construction

There is more to a comet than just its spectacular tail

Comets are thought to be among the oldest objects that exist in our Solar System. Many spend the vast majority of their lives slowly drifting through the darkness towards the edges of our planetary neighbourhood. While they're most famous for their tails, these are only transitory features that develop as they briefly swing into the inner Solar System. Here we've broken down the main components of a 'typical' comet as it approaches the Sun.

1 TAILS

Occasionally a comet will develop a tail consisting of countless dust particles which have been sprayed from the nucleus as it gets heated in the light of the Sun. Sometimes a second 'ion' tail – composed of gases released from the nucleus – can form too.

2 NUCLEUS

A comet's nucleus is its irregularly-shaped heart made of ices – including carbon dioxide ice and water ice – as well as dust and other materials. The European Space Agency's Rosetta mission showed that the double-lobed nucleus of Comet Churyumov-Gerasimenko has an extraordinary landscape of boulder fields, pits and cliffs.

3 COMA

The coma of a comet is the swirling envelope of gas and dust immediately surrounding the icy nucleus. Often the coma will glow a characteristic turquoise-green colour, which can sometimes be seen in binocular or telescope views.

ILLUSTRATION

NASA/ESA/H. WEAVER (APL/JHU) M. MUTCHLER AND Z. LEVAY (STSCI), MARTIN GEMBEC, NASA/ESA/AND D. JEWITT (UCLA), DETLEV VAN RAVENSWAAY/SCIENCE PHOTO LIBRARY

▸ "We secretly hoped, but wouldn't have really guessed that ATLAS would break apart a bit before our scheduled observation – that was a really pleasant surprise," says Ye. "Our observation happened overnight and I woke up quite early the next day. It felt like opening a gift box when I was downloading the data." Another group of researchers had also been allocated observing time as well, and in total three orbits of the space telescope would eventually be dedicated to scrutinising the spectacle occurring out in space.

The dramatic pictures from Hubble, captured by both teams, showed large chunks of the comet whirling through space within a chaotic cloud of icy debris. "Since we have images from three different epochs, we can measure the changes in brightness and velocity distributions of the fragments; like how the fragments move with respect to each other and how they fizzle out," explains Ye. "These will help us to understand the mechanism that drives the fragmentation of the comet, which will in turn tell us how the nucleus was held together."

▲ Hubble images of Comet 73P/ Schwassmann-Wachmann 3 show it breaking up in April 2006

Will Gater is an astronomy journalist and science presenter. Follow him on Twitter at: @willgater

▲ An image of Comet ATLAS taken in March 2020 before it broke up. Scientists studied the light from the comet both before and after it fragmented

Not only can studying a comet's disintegration provide specific clues to its construction, it also has the potential to reveal details about processes that were going on in the Solar System long ago. "One of the most interesting questions to ask is if the fragments have compositional differences," says Laura Woodney. This can give insights into the distribution of different materials within the nucleus – something that can illuminate the broader formation history of comets and icy planetesimals.

Clues about our Solar System

For Dr Ekaterina Chornaya, and her colleagues at Russia's Far Eastern Federal University and elsewhere, the demise of ATLAS provided a glimpse at the interior constituents of a comet's nucleus – one that would also shed light on its origins. "Comets or, speaking more precisely, their nuclei are widely thought to be fossils from the time of our Solar System's formation," says Chornaya. "They are remnants of planetesimals which were thrown out of the inner part of the Solar System during or shortly after its formation."

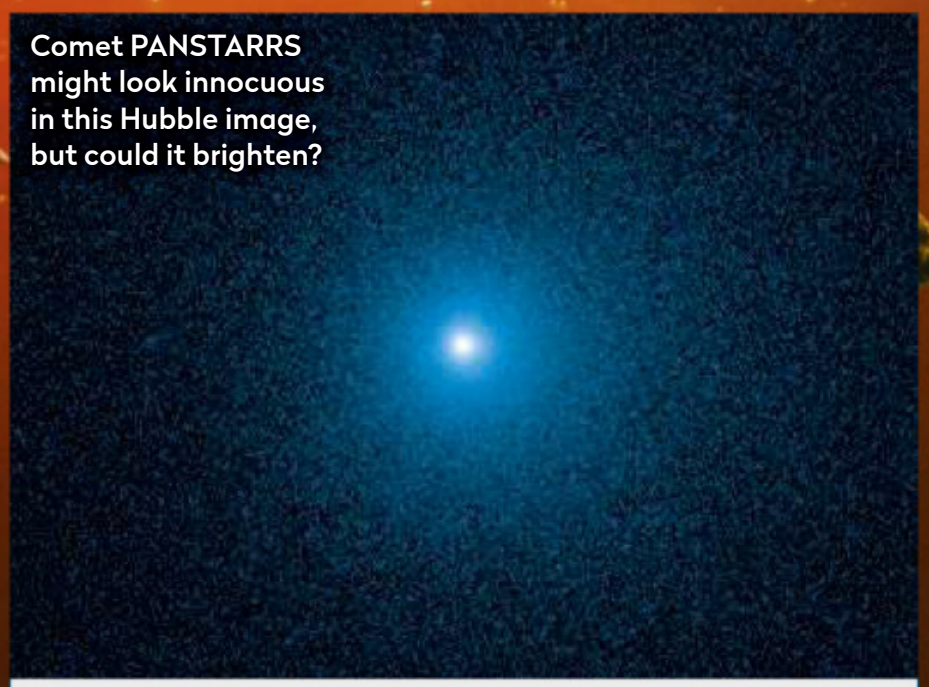
Some comets might have been flung into the frozen realms at the Solar System's edge early on in that period, before the Sun even switched on, says Chornaya. There they would have been kept in a largely pristine state. Others may have lingered for a while in our star's warmth, prior to being ejected outwards. "In the latter case, [a comet's] surface may experience a significant weathering due to frequent heating and micro-meteoroid bombardments," she explains.

Piecing together the details of such ancient history from their apparent composition is one of the challenges planetary scientists face with comets. "When observing a comet upon its return to the inner Solar System, in general, we see not only its pristine materials, but also significantly altered materials," says Chornaya. "The point is that we do not know the fractions of each type of materials in a given comet."

As ATLAS broke apart it opened up an extraordinary window onto the pristine contents of its heart, however. Utilising a half-metre aperture telescope sited at the Ussuriysk Astrophysical Observatory, Chornaya and her fellow researchers

Ancient relics: many comets are thought to have been flung out from the inner regions of the Solar System when it was forming

ILLUSTRATION



Comet PANSTARRS might look innocuous in this Hubble image, but could it brighten?

The next bright comet?

Predicting which comets will brighten is notoriously hard

Whenever the subject of observing comets comes up, there's always one thing that every astronomer wants to know: when's the next bright one going to appear in our skies. Professor Laura Woodney suggests C/2017 K2 (PANSTARRS) could be one to keep an eye on. "Given the way it has been increasing in brightness since its discovery, it is currently on track to be a sixth magnitude object in 2023. While that's not nearly as bright as C/2020 F3 (NEOWISE) is now, 2017 K2 is still at [roughly] 8.5 AU, so lots of things could happen as it nears the Sun and water sublimation [begins] in a few years," she says. "Maybe it will break up or fizzle, maybe it will only be interesting for telescope observations – or maybe it will become bright enough for all to see. We'll just have to wait!"

studied the light from ATLAS both before and after it fragmented. "We were lucky to catch the comet prior to its disintegration," says Chornaya. "This makes it possible to draw a whole picture and it is a quite unique chance."

Ancient treasures

The team's observations showed the relative amounts of certain substances changing as the comet crumbled – something that could hint at what the make-up of unaltered cometary material is. The researchers also detected a conspicuous rise in the amount of carbonaceous dust particles swirling around the disintegrating comet's coma; these microscopic particles are relics from the birth of the Solar System and a sign of the truly ancient nature of the comet's interior. That's because, today, those tiny flecks would be blown far from our planetary neighbourhood by the light – technically the 'radiation pressure' – from the Sun. The fact the signs of them appeared in the light from ATLAS indicates they were incorporated within the comet's nucleus long, long ago – prior to the point when the Sun began shining as it does now.

At the time of writing, no one knows what's become of the debris of Comet ATLAS; its orbit has temporarily taken it behind the blazing light of the Sun where it can't be observed. "If there are any larger bits that survive perihelion, they will continue their journey into deep space and return in another 6,000 years," says Ye Quanzhi.

Yet even if nothing remains, ATLAS has told us so much already. Perhaps the next time a comet fizzles before our eyes, those initial pangs of disappointment may turn to excitement at what we might learn from the disintegration of these amazing objects.

The fundamentals of astronomy for beginners

EXPLAINER

Make more of the season of dark skies

The new astronomy season this autumn and winter has some lovely lesser-known targets

▲ **Kemble's Cascade is a wonderful string of colourful stars, easily spotted with binoculars**

STOCKTREK IMAGES/INC./ALAMY STOCK PHOTO, STEVE MARSH, BERNHARD HUBL/CCDGUIDE.COM X 2

As we move into darker skies, the winter constellations hold a treasure trove of beautiful objects. Although we are often drawn to the more familiar targets (see Old favourites, opposite), it pays to seek out some lesser-known night-sky jewels that are just as rewarding.

First, two highlights of the year. Mars reaches opposition on 13 October, when its apparent size is at its greatest. The Red Planet is visible for months after opposition, so observe it regularly to see its apparent diameter changing. Venus is blazing in the pre-dawn eastern sky during October, and on 14 October is joined by a waning crescent Moon.

Then Jupiter and Saturn will be very close together in the sky on 21 December. Found low in the western sky, they will easily fit within the field of view of a large telescope.

On the Moon, clair-obscur effects are some of the most intriguing phenomena to observe. One of the most well known is the Lunar X, which you can see on 22 November from 16:00 UT.

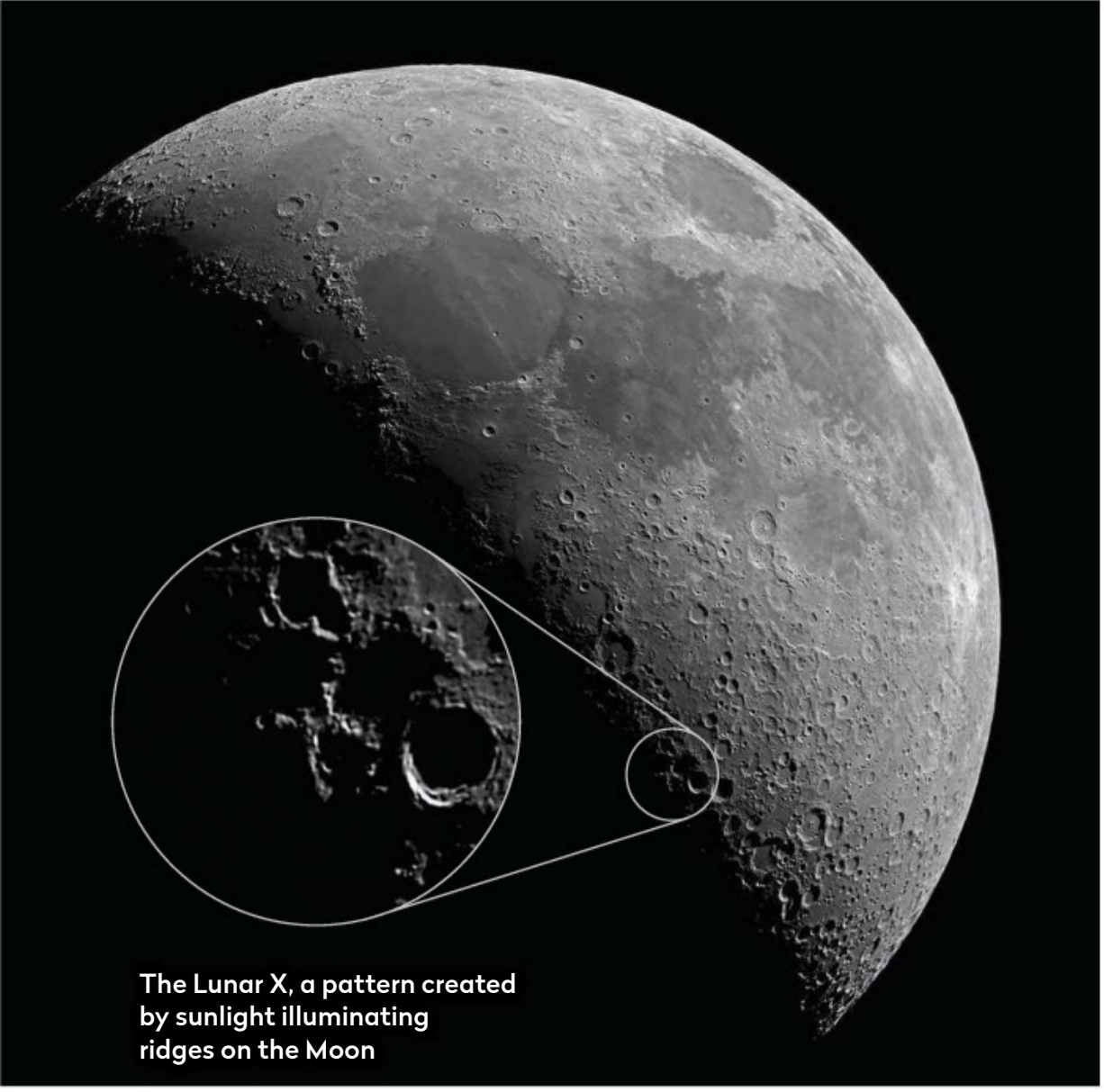
On to asterisms, and Kemble's Cascade, in the constellation of Camelopardalis, is a chain of 15 colourful mag. +5 to +8 stars, with open cluster NGC 1502 at one end. Observe it on early evenings during November and December through binoculars or a small telescope and it will look like a vertical cascade of stars tumbling into the open cluster at the bottom.

Galaxy quest

Another lovely asterism of 40 or so mag. +5 stars is the Leaping Minnow and 'Splash' in Auriga. Spot them from early October, when they rise in the northeast from 19:30 UT onwards. The constellation of Auriga climbs higher in the sky over subsequent months and will be well placed throughout the winter season.

Colour contrasting double stars are beautiful, and a great example is Cor Caroli in the constellation of Canes Venatici. Well-placed in the late evening in February, it can be seen through a small scope. The primary star shines blue and, at mag. +2.9, is almost 10 times brighter than its mag. +5.6 yellow-orange companion star. At low magnifications you may also see the small barred spiral galaxy M94 nearby.

On the subject of galaxies, spring is often called 'galaxy season' because so many are observable at that time of year, but if you stay up until after midnight you can see many great targets from mid-December onwards. Ursa Major is home to a



The Lunar X, a pattern created by sunlight illuminating ridges on the Moon

lovely pair: spiral galaxy M81 (Bode's Galaxy) and irregular galaxy M82 (the Cigar Galaxy). They easily fit into the same field of view with a small telescope and they are extremely photogenic.

Leo is teeming with galaxies and a good place to start is the Leo Triplet group of three spiral galaxies: M65, M66 and NGC 3628. These can be seen together through a small telescope, but you will need dark skies and time for your eyes to dark-adapt to see them visually. This trio is best observed when it's more than 18° above the horizon; in mid-December that's well after midnight. Leo will reach this altitude two hours earlier each month, so by February it is observable by 20:30 UT. Another double star, Algol, is the second brightest star in Perseus and is well placed every night during the coming months. It is an eclipsing binary system whose magnitude changes between +2.1 and +3.4 over a period of 2.87 days. Use the nearby mag. +2.1 star Gamma (γ) Andromedae for comparison.

Finally, during spring, Leo plays host to minor planet 4 Vesta. It becomes an achievable binocular target around the beginning of February when it is mag. +7.9, but it will brighten to +5.9 as it reaches opposition on 4 March, before fading again. It's visible all night long during February and March. Vesta will move relative to the background stars every night, so learn the star field and follow its journey through Leo. On 21 March, it passes close to mag. +11.4 barred spiral galaxy NGC 3507. You will need a large aperture telescope to see this conjunction visually, but it will show up more easily in photographs.

So you see, the long, dark evenings of winter need not be depressing: if you know where to look they're a boon. Get outside and get looking up!

▲ Find the Leo Triplet close to the Lion's back leg, where all three spirals can be seen with a small telescope

Mary McIntyre is an Oxford-based astronomer and astrophotographer

▲ A favourite for many, the stunning Orion Nebula, M42, is on show right through until late March

Old favourites

As well as new targets, it's always good to go back to the classics. Here are some autumn and winter night-sky stalwarts

THE ORION NEBULA is one of the easiest nebulae to observe and is great to photograph.

THE PLEIADES is a stunning open star cluster surrounded by bluish-white gas and dust.

THE GEMINID METEOR SHOWER peaks on 13/14 December, with no Moon to interfere in 2020.

THE ANDROMEDA GALAXY is an easy target for binoculars and small telescopes.

THE TRIANGULUM GALAXY is about 15° below the Andromeda Galaxy and well worth seeking out.

THE BEEHIVE CLUSTER is a gorgeous large and colourful star cluster located in Cancer.

THE DOUBLE CLUSTER between Perseus and Cassiopeia is fantastic for binoculars and small telescopes.

BETELGEUSE is a red giant star on Orion's left shoulder. Compare its colour with blue giant Rigel on Orion's lower right.

DIY ASTRONOMY

How to collimate a Newtonian telescope

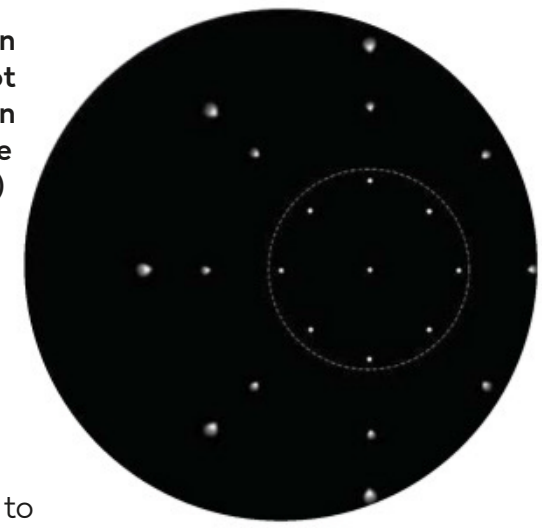
Discover how to optically align your Newtonian and avoid distorted views

Enhanced performance: to get the best from your Newtonian it needs to be properly collimated

Newtonian reflector telescopes are perennially popular for amateurs for their relatively low cost for any given aperture and their naturally good colour correction. But due to the loose way in which a Newtonian's two mirrors are typically held, this design of telescope can lose its optical alignment relatively easily, especially when compared with more robust telescope designs like refractors. The process of bringing the mirrors back into optical alignment is referred to as collimation.

Collimation is about getting a Newtonian's 'sweet spot' in the centre of the view through the eyepiece. This sweet spot is where stars appear sharpest: it's the circular area on a Newtonian's main mirror where light is focused to maximum resolution. Outside the sweet spot star images appear larger and get distorted into V-shapes. This distortion away from the centre of the view is present in all Newtonians, even perfect ones; it's called coma as it makes the stars look like mini-comets.

If the mirrors in the telescope become slightly misaligned – as a result of a knock or changes in temperature – the sweet spot can move away from the middle of the eyepiece's field of view and end up off-centre. If this happens the middle of the eyepiece view will be looking at an area of inferior quality outside the sweet spot. Collimation realigns the mirrors to bring the good area back to the middle of the eyepiece field, restoring the best star images and allowing you to see the most planetary detail. Although the job of collimating a Newtonian may seem daunting if you've never done it, once you have the right tools and understand the principles, it becomes relatively quick and easy.



► Before: the view through a scope in need of collimation, with a sweet spot off-centre (top) After: the same view in a well-collimated Newtonian, with the sweet spot in the centre (below)

Size of sweet spot is another aspect to bear in mind. In a Newtonian it is dependent on the ratio between the telescope's focal length and the diameter of its main mirror. For telescopes where this ratio is relatively low (short, wide scopes) the sweet spot is small: for these scopes regular collimation is crucial so that objects at the centre of the view can be seen at their best. Much more so than for Newtonians with a higher ratio (long and relatively thin): they will have a much larger sweet spot and will be far more forgiving of small amounts of misalignment. For these scopes collimation is less critical and can be done much less frequently.

Our Step by Step guide opposite describes a relatively easy way to re-collimate your Newtonian telescope with simple tools, by making small adjustments to the secondary mirror assembly and to the primary mirror cell. We're not using a laser-based telescope collimation device here; these do allow precision alignment but add an extra layer of complexity. Instead, keep things simple and you'll learn how to quickly collimate your Newtonian scope.

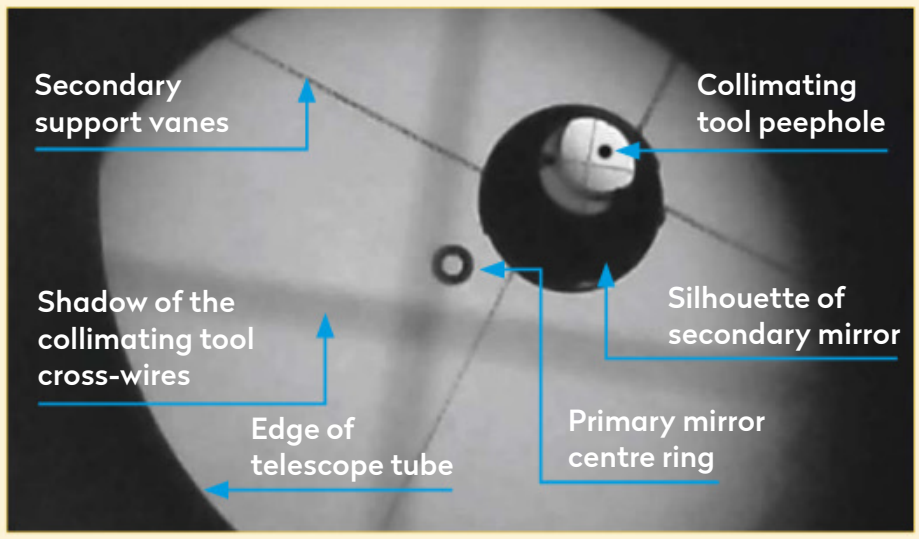
Martin Lewis is an expert astronomer and planetary imager

What you'll need

- A Cheshire eyepiece collimating tool that has a sight tube with cross-wires
- A screwdriver to turn the adjuster screws on the secondary mirror
- A torch to illuminate your Cheshire eyepiece at night

ALL PICTURES: MARTIN LEWIS

Step by step

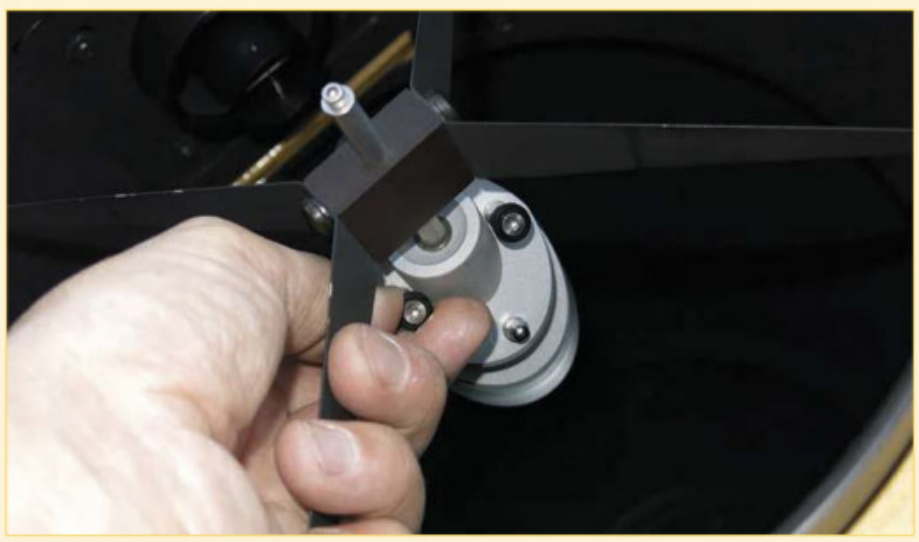


Step 1

Do your first collimation in the daytime, when you can see what's going on. Secure your Cheshire eyepiece collimating tool in the focuser with the open side facing the sky to let light in. Next, point the scope at the bright sky, but well away from the Sun.

Step 2

Familiarise yourself with the view through the collimating tool's eyehole. What you see may be confusing at first, so compare your view with the labelled image above for a mis-collimated scope. This will help you to identify the features that need to be repositioned.

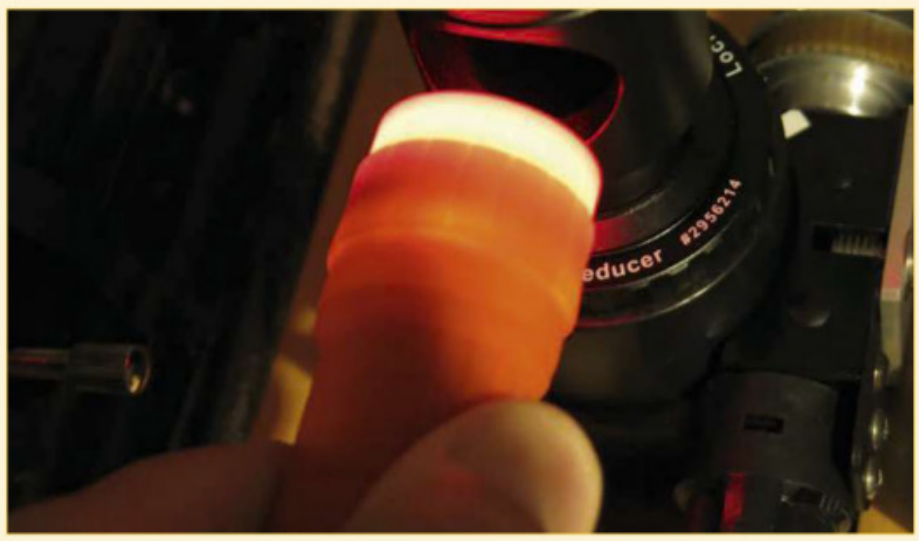


Step 3

Through the tool's eyehole look for the centre ring on the primary mirror. Move the secondary mirror with the adjuster screws to bring this ring under the point where the shadow of the cross-wires intersect. You may need a screwdriver or other tools for this.

Step 4

When the first stage of collimation is done the view should look like the one above, with the centre ring on the primary mirror right under the middle of the cross-wire shadows. Tighten up the secondary mirror screws, being careful to maintain alignment.



Step 5

Now align the primary mirror using its adjustment screws, until the peephole spot is centred in the main mirror's centre ring. If you moved the primary a lot you may need to re-check the secondary alignment, but otherwise your scope's collimated and good to go!

Step 6

Next time you perform any fine-tuning collimation it may be at night. In this case, shine a red torch into the side of the collimating tool to illuminate the middle of the cross-wires and show the dark collimating tool's eyehole.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Imaging lunar libration

Capture contrasting images that reveal the 'extra' areas at the Moon's edges

▲ **Thanks to its elliptical orbit and tilt, we can actually image slightly more than half of the Moon's surface**

ALL PICTURES: PETE LAWRENCE

The Moon is gravitationally locked to Earth, rotating once on its axis in the same period of time that it takes to orbit our planet. For us on the ground, this means we see the same familiar face of the Moon all the time. There is, however, a small variation in the Moon's appearance over time, due to an effect called 'libration'. This describes the cumulative effects introduced by the elliptical nature of the Moon's orbit and its tilt relative to the orbit of Earth.

The Moon's elliptical orbit means that its orbital speed around Earth varies over time; when it's closest to our planet at perigee its speed is highest, and when it's furthest from Earth at apogee its orbital speed is at its lowest. This variation allows us a peek around the eastern and western limbs of the Moon over time.

The Moon's orbit is tilted to that of Earth by about 5° too, causing the Moon to appear to move above and below the ecliptic. As it does so, we effectively peek over the southern and northern edge of the Moon by a small amount. Together, these libration effects allow us to see 59 per cent of the Moon's surface, which is 9 per cent more than if the Moon was rigidly locked to Earth.

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

One good way to see libration is to look for the elliptical sea known as Mare Crisium, close to the Moon's northeast limb. At extreme librations, this can look close to the Moon's limb or quite far away.

Catch two Moons

By capturing images of two different moons you can see the differences in the positions of features caused by libration. October is a perfect opportunity to try this as there are two full Moons; the first rises at 19:15 BST (18:15 UT) on 1 October and it should be possible to get a decent shot from 21:00 BST (20:00 UT). The second is on the 31st, rising around 17:00 UT and favourable from 19:00 UT.

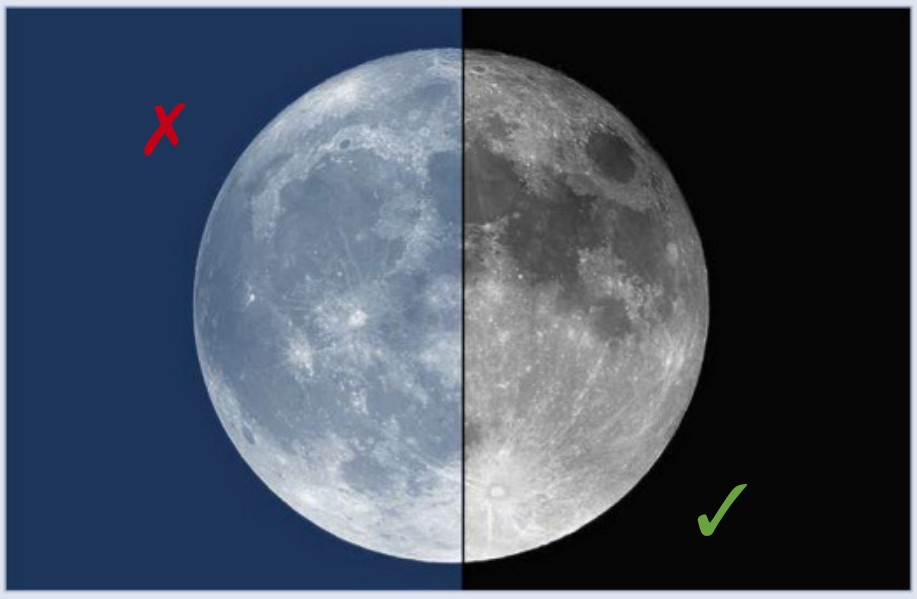
Once you've grabbed images of both, you can overlay them so that the features almost line up – they won't precisely because of libration. The variation can be highlighted in a number of ways. For example, placing both images side by side, the minor differences in positions of features should be noticeable. A more dramatic method is to create an animated image which flicks between both versions.

The visibility of libration on a large scale (eg, in a full disc image) depends on the variance between latitude and longitude libration values over the comparison period. Another more ambitious project can be achieved by attempting to photograph every phase of the Moon over a month. The biggest hurdle to overcome here is the British weather; you would have to be very lucky to be able to catch one phase every day over a month, but it may be possible to grab shorter sequences that still show the effects of libration.

Recommended equipment: 1,000mm focal length telescope, DSLR camera or equivalent

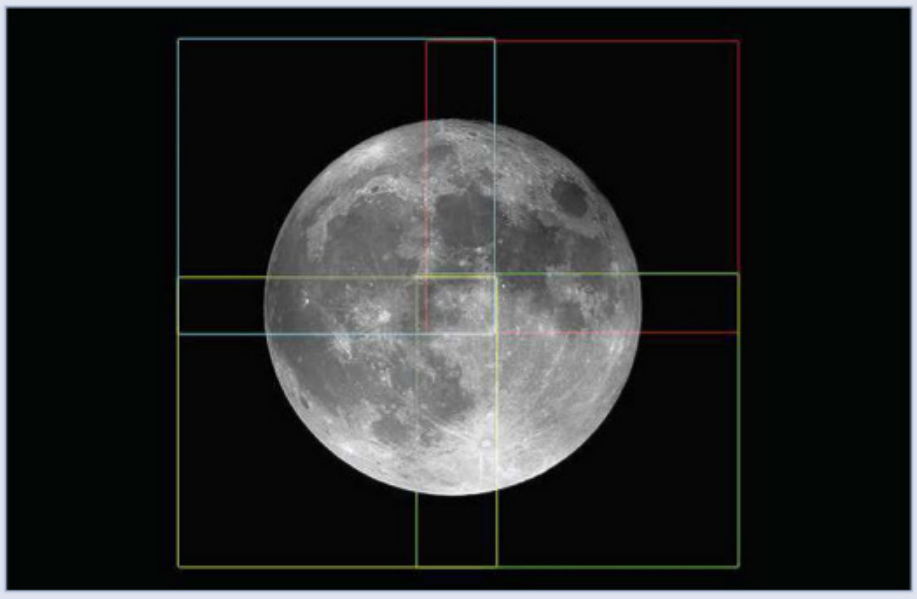
✉ Send your images to:
gallery@skyatnightmagazine.com

Step by step



STEP 1

Plan your shots; the best results will be achieved if you capture photographs under similar conditions. Select a time when the sky will be dark, as this will provide maximum contrast, but also removes any variation in appearance caused by blue or twilight-lit background skies.

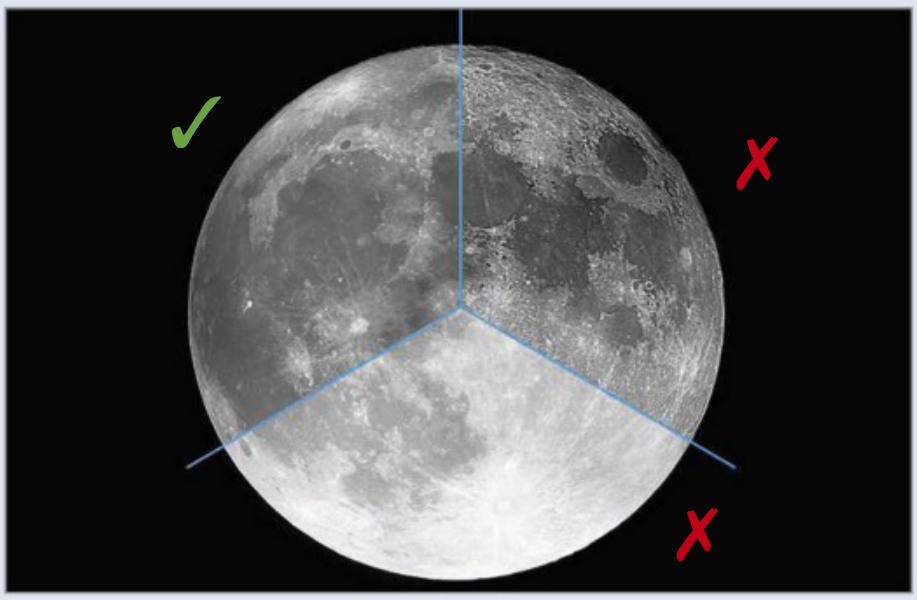


STEP 2

Select the right focal length for the task; an optimum setup is one that clearly shows lunar features beyond just the dark seas. A telescope with a 1,000mm focal length will work well with a DSLR or MILC-type camera. Alternatively, a narrower field of view can be used to create a large-scale mosaic.

STEP 3

For mosaic shots, we'd recommend using a setup that includes a high frame rate camera. A mono camera paired with a red or infrared pass filter can also help keep features nice and sharp. Don't be overly ambitious: limit the overlapping mosaic panels to a maximum of nine; even two or four should suffice.

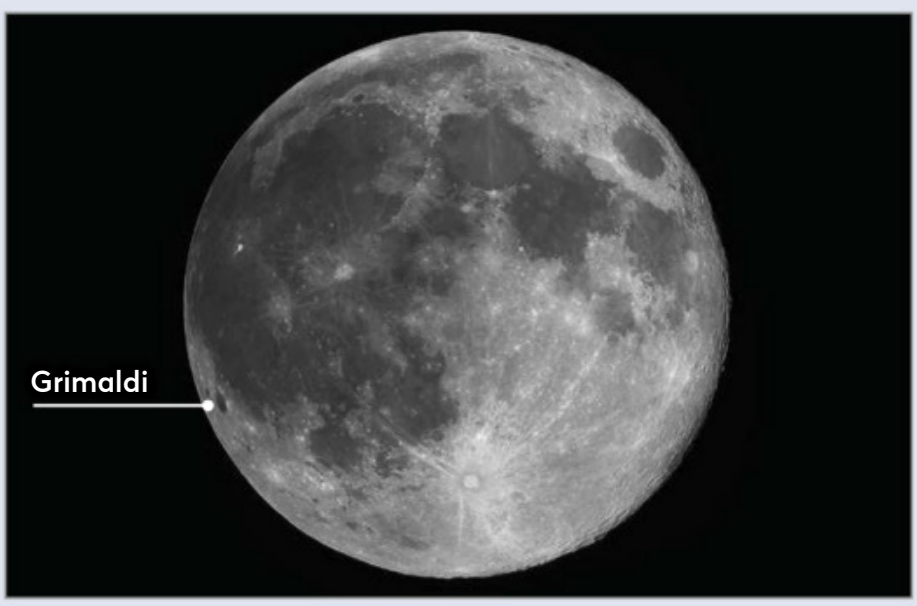


STEP 4

Process your images to the best of your ability and aim to produce natural-looking discs without over-exposed (white) or under-exposed (black) regions. Sharpen the disc to crispen up features, but take care not to overdo things; it helps to load both full Moon images at once and apply the same level of processing to each.

STEP 5

Load both images into a layer-based image editor as separate layers. Make the upper layer semi-transparent and adjust the sizes so the disc edges match. Don't worry about feature orientation at this point; crop/adjust the canvas size so the image is square, with the centre of the Moon's disc in the centre of frame.



STEP 6

With the upper layer still transparent, rotate it so the dark crater Grimaldi appears close in both versions. Make the upper layer opaque and increase canvas width by 200%, placing both discs side by side. Alternatively, if your program allows it, create a 1-sec flick book-style animated GIF which switches between both versions.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

IIAPY Masterclass

The wonder of the Northern Lights

How to construct a panorama that captures the mystery of an aurora display

Insight Investment **Astronomy Photographer of the Year**

Advice from the 2019 winner of the 'Aurora' category

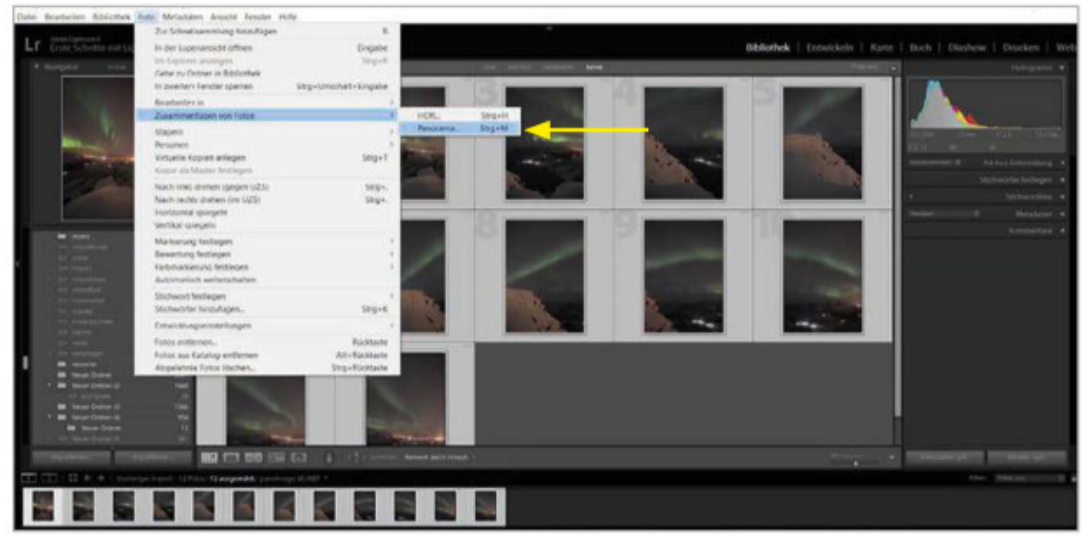
'The Watcher': Nicolai Brügger's award-winning aurora shot

ALL PICTURES: NICOLAI BRÜGGER

When my image entitled 'The Watcher' won the 'Aurora' section of the 2019 Insight Investment Astrophotographer of the Year competition I was delighted. The final image (above) shows a view looking down on Norway's Lofoten archipelago from Offersøykammen mountain. I chose the location because I like mountains and there aren't many photos taken from this viewpoint. During the day I climbed the peak with a friend – he's the person standing in the picture – and took pictures of the sunset, before waiting until it got dark. I took multiple images with the aim of creating a panorama of the wonderful aurora display that was taking place. When I set about processing the image, I wanted a result that would reflect just how special the moment was; I wanted to ensure that there were no areas that were too light or dark, and that the colours remained true to nature, with just a little bit of highlighting to bring out more detail. (**The screenshots shown here use my German language versions of Adobe Lightroom and Photoshop; I've translated the commands indicated by yellow arrows into English**.)

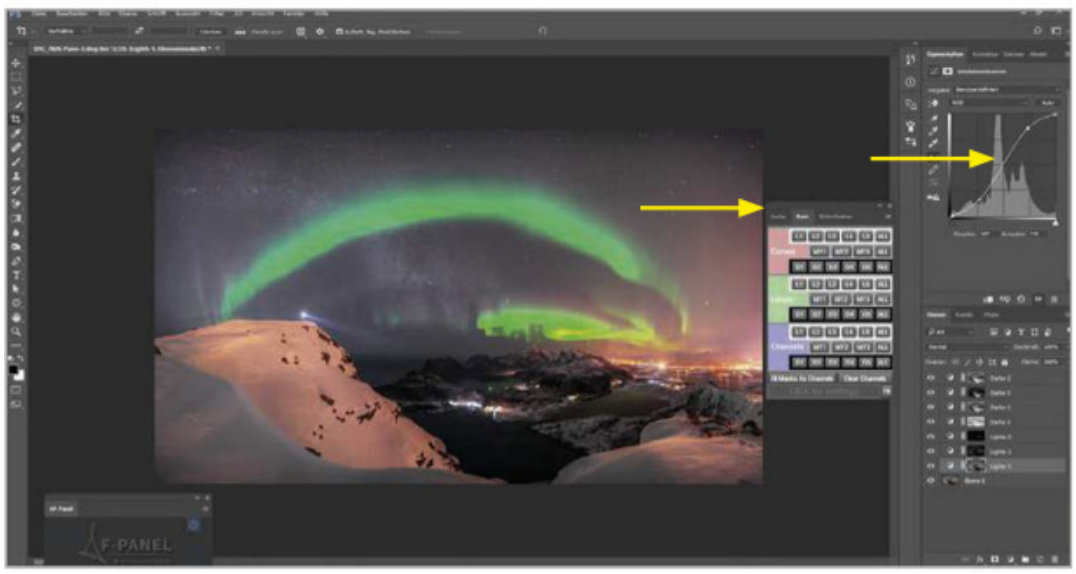
Panorama of drama

My first processing step involves the creation of a panorama in Adobe Lightroom. To do this I select the RAW images required from my photo library and mark them (see Screenshot 1, below). The selected pictures are joined together to make the initial panorama by clicking on 'Photo › Merge photos › Panorama' ['*Foto › Zusammenfügen von Fotos › Panorama*']. The completed RAW panorama can now be imported into Adobe Photoshop, ready for me to perform basic adjustments with the RAW converter (see Screenshot 2, opposite). I adjust the 'Highlights'

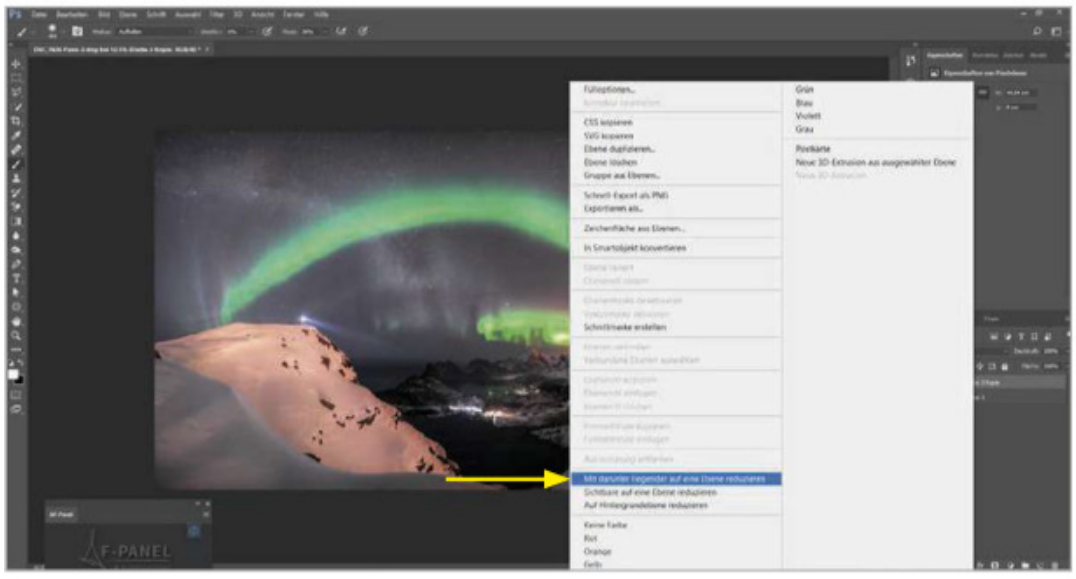


▲ **Screenshot 1: The panorama images are selected in Lightroom: 'Photo › Merge photos › Panorama' ['*Foto › Zusammenfügen von Fotos › Panorama*']**

▲ **Screenshot 2: The panorama is imported into the German language version of Photoshop for tweaks in the RAW converter, including to 'Highlights' ['*Lichter*'], 'Shadows' ['*Tiefen*'], 'Whites' ['*Weiß*'] and 'Blacks' ['*Schwarz*']**



▲ **Screenshot 3: Adjustments to bright and dark tones are made using luminosity layer masks: an 'S' curve (top) can be created to adjust the 'Lights' and 'Darks'**



['*Lichter*'] slider, bringing it down completely, while the 'Shadows' ['*Tiefen*'] are adjusted up. I make tweaks to the 'Whites' ['*Weiß*'] and 'Blacks' ['*Schwarz*'] by eye, to +31 and –8 respectively, but this is down to personal taste. By adjusting the 'White Balance' ['*Weißabgleich*'] towards blue, the snow appears white and not too greenish. I boost the 'Contrast' ['*Kontrast*'] and move the 'Clarity' ['*Klarheit*'] slider up to +10 in the foreground and down in the background, with slight tweaks to the 'Brightness' ['*Helligkeit*']. After removing noise with the 'Noise Reduction' ['*Rauschen reduzieren*'] tool, I'm ready to move on from the RAW converter.

▲ **Screenshot 4: The layers can be combined (above), by selecting 'Reduce to one level with one below' [*'Mit darunter liegender auf eine Ebene reuzieren'*]**

3 QUICK TIPS

1. Calibrate the screen to get the best colours in your final image, as devices often have a different white balance.

2. Check the internet for plug-ins or tools that make your work easier, or to find new effects.

3. Look at your finished picture again on the next day, as you'll often find something that's been overlooked.

The next stage involves working with luminosity layer masks (see Screenshot 3) in Photoshop. I find the plug-in TK Basic panel tool is useful for making luminosity masks, because it's an easy way to create layers automatically. Within a layer you can create an 'S' curve in the 'Tone Curve' ['*Gradationskurven*'] panel, which represents portions of the image; this darkens the shadows in the lower third of the curve and lightens the brighter portions of the image represented by the curve's upper third. I make an 'S' curve for all the lighter tones, or 'Lights' (marked as L1 to L5 in the tool) so that they shine beautifully; I leave the middle tones untouched when I process night shots. I then draw an 'S' curve for the 'Darks' (marked D1 to D5). The exception is 'Darks-1', the category's first section, where I boost the shadow to make the image brighter and more natural.

The 'Lights' can be enhanced more by using the brush tool over an extra layer (created by making a copy from the image to a new layer by right-clicking the mouse). In Photoshop's 'Lighten' blend mode I move a soft brush with low 'Opacity' over the areas of city lights, snow and aurora. I do the same for dark-shaded areas in the 'Darken' mode. After this I pull the two layers (the copy and the original) together, with a right click on the copy layer, and combine with the lower layer (Screenshot 4,).

Finishing touches

Finally, I add a softening effect by drawing over the lights with the soft brush tool and making them shine, to give the picture a nice, glowing look. By using the AF-panel, the effect is possible with a mouse click. I'm careful to only apply this effect to the light areas, leaving the dark areas untouched – otherwise the picture can lose its coherence and look blurry. The AF-panel automatically makes a perfect layer for that, so there's no need to create extra ones. After that I sharpen the image with the RAW converter. I may need to make more tweaks to 'Saturation' or turn the 'Dynamic Range' lower, as these can often change during the editing process and result in the snow losing whiteness. To finish, I save my aurora image as a high resolution JPEG.

Nicolai Brügger is a photographer who lives in Germany. He won the 'Aurora' category at the IIAPY in 2019 with 'The Watcher'

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More **ONLINE**
A gallery containing these and more of your images

PHOTO OF THE MONTH

△ The Statue of Liberty Nebula, NGC 3576

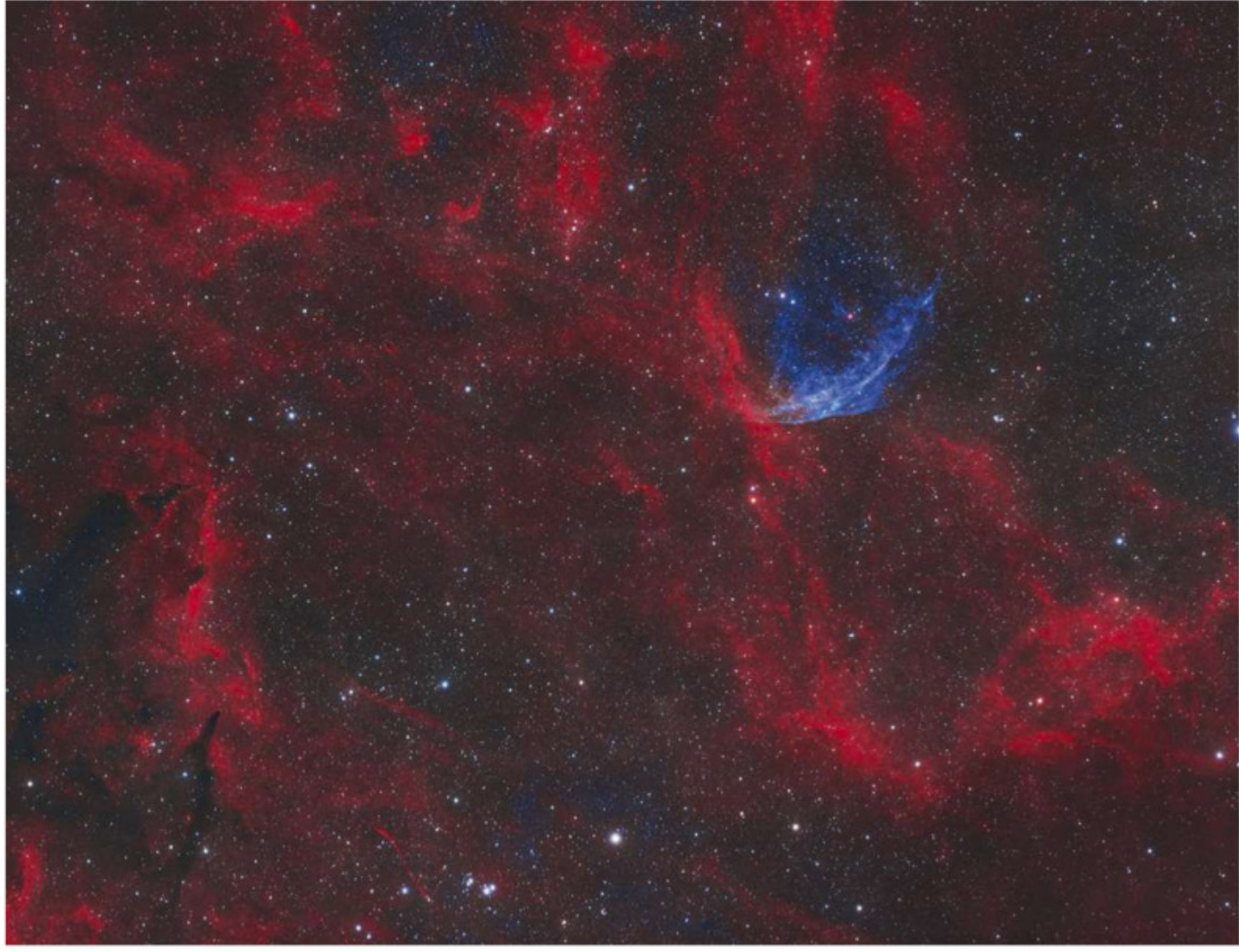
Nicolas Rolland, via El Sauce Observatory, Rio Hurtado, Chile, January and February 2020

Nicolas says: "I like this image because it represents a real pareidolia game, without good or bad answers; as well as the distinctive shape of the Statue of Liberty, you can also make out a dragon head and a crocodile side. You can let your imagination run wild. From a scientific point of view, it showcases dense knots of dark interstellar dust, bright stars formed a few million years ago and huge fields of glowing hydrogen gas ionized by these stars."

Equipment: SBIG STXL-11002 camera, PlaneWave 17" CDK astrograph, Paramount ME mount **Exposure:** Ha, SII, OIII 20 x 1,800" each, RGB stars 8 x 1,200" each: 36.6h total **Software:** CCDstack, PixInsight, Photoshop

Nicolas's top tips: "Astrophotography takes hours – even more with processing, but don't hesitate to start again if you're not satisfied with the results. Be selective by using only your best frames for stacking and share your pictures to get feedback. This picture has been colour-mapped: with monochrome narrowband data assigned to colours using the Hubble palette (SII: red, Ha: green and OIII: blue) and H-alpha data applied as a luminance to improve the nebulosity's structure."

WR134 ▷



Daniel Hightower, California, 15 July 2020

Daniel says: "This was an extremely challenging target for me and, at 50 hours, my longest exposure attempt. I wasn't sure the OIII (Oxygen-III) would be prominent enough to see the structural detail of the expanding gas, but I was pleasantly surprised when I integrated all of the data."

Equipment: ZWO ASI 1600MM Pro camera, Takahashi FSQ-106EDX4 quadruplet refractor, Orion HDX110 mount
Exposure: Ha 300 x 300", OIII 300 x 300"
Software: SG Pro, PixInsight

△ Fireball and NEOWISE

Steve Sheehan, King's Meaburn, Cumbria, 21 July 2020

Steve says: "I was set up in the back garden, taking a series of exposures of Comet NEOWISE, when this fireball streaked across the sky. I've been trying for years to get a really good meteor shot – I think all my Christmases came at once with this one!"

Equipment: Sony A580 DSLR, 18–70mm lens
Exposure: ISO 3200 f/5.6, 8" **Software:** Photoshop

▽ Daytime Moon

Dan Fleetwood, Rugby, Warwickshire, 27 July 2020

Dan says: "The clouds briefly parted for the first time in over a week, unveiling a lovely and clear daytime Moon. A quick setup of some new equipment helped me capture this – the first image through my new refractor."

Equipment: Canon EOS 250D DSLR, Sky-Watcher Evostar 72ED refractor, Sky-Watcher Star Adventurer mount **Exposure:** ISO 100, f/5.6 **Software:** Lightroom

△ The Eastern Veil Nebula

Haim Huli, Israel, July 2020

Haim says: "One of the biggest challenges doing astrophotography from a very light-polluted area is getting good colours. I did most of the RGB at the zenith to avoid as much light pollution as I could. I was surprised that the final colours came out so beautifully."

Equipment: QSI 583wsg mono camera, Sky-Watcher P250 Newtonian, Sky-Watcher EQ6 mount **Exposure:** Ha 183 x 5', RGB 34 x 33' each
Software: MaximDL, Photoshop

△ Dark nebulae LDN778, LDN768 & vdB126

Wayne Stallard, Basildon, Essex, 30 July 2020

Wayne says: "I've always been fascinated with all the different shapes and forms dark nebulae take. It was a challenge to get the correct colour balance, but I'm very happy with how it turned out."

Equipment: QHY268C camera, William Optics WhiteCat 51mm apo refractor, Sky-Watcher EQM Pro mount **Exposure:** 82 x 2'
Software: MaxIm DL, PixInsight, Photoshop

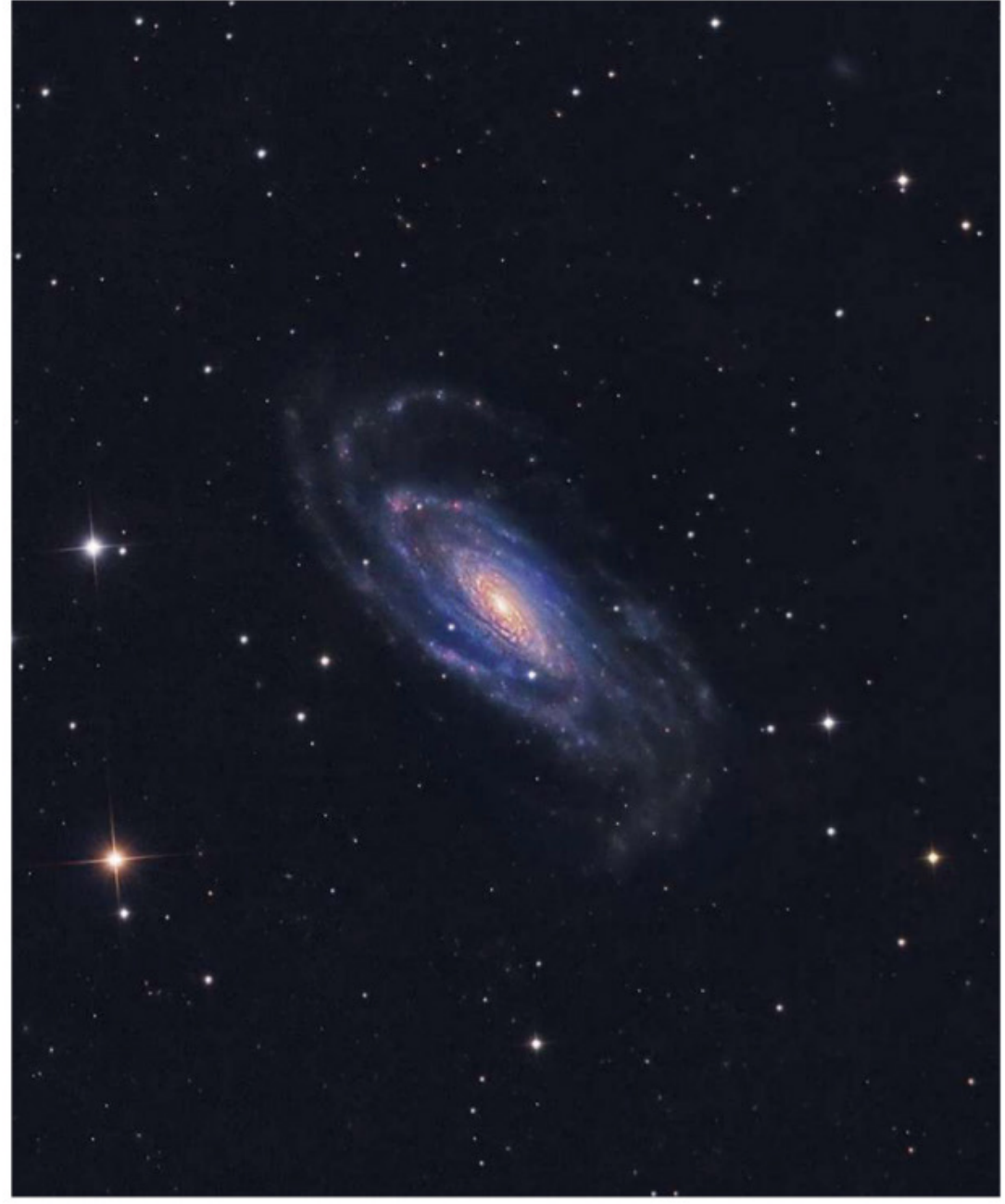
▽ The Dumbbell Nebula, M27

Tom Wildoner, The Dark Side Observatory, Pennsylvania, USA, 25 May 2020

Tom says: "No summer is complete without imaging this nebula. This was my first time using the automated focus routines in Sequence Generator Pro software – what a difference it's made when imaging in warmer weather, eliminating the need to 'babysit' the focuser."

Equipment: ZWO ASI 071MC-Pro camera, Meade LX90 SCT, Celestron CGEM DX mount
Exposure: 58 x 60" **Software:** SG Pro, PixInsight

NGC 5033 ▷



Tony Funnell, Worthing, Sussex, 12 and 14 April 2020

Tony says: "I love this galaxy, but it's tricky to process. The arms fade into the background sky, and getting the core detail is tricky as it's bright relative to the rest of the galaxy."

Equipment: QSI 683 mono camera, 12" Ritchey-Chrétien telescope, Mesu 200 mount **Exposure:** L 36 x 10', RGB 4 x 10' each **Software:** PixInsight, Photoshop

▽ Moon, noctilucent clouds and rising Venus

Andrew Allan, Perth, Scotland, 19 July 2020

Andrew says: "After hunting Comet NEOWISE all night, I thought I'd hold on for the thin crescent Moon to rise. Luckily for me, a fantastic show of noctilucent clouds (NLCs) started to form and Venus was within range to capture in one single image too."

Equipment: Canon 1300D DSLR, 75–300mm lens **Exposure:** ISO 800, f/5.6, 2" **Software:** Lightroom

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Every year, we carry out research on behalf of BBC Studios that invites readers to share their views about this magazine and other BBC Studios titles.

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BBC Sky at Night MAGAZINE

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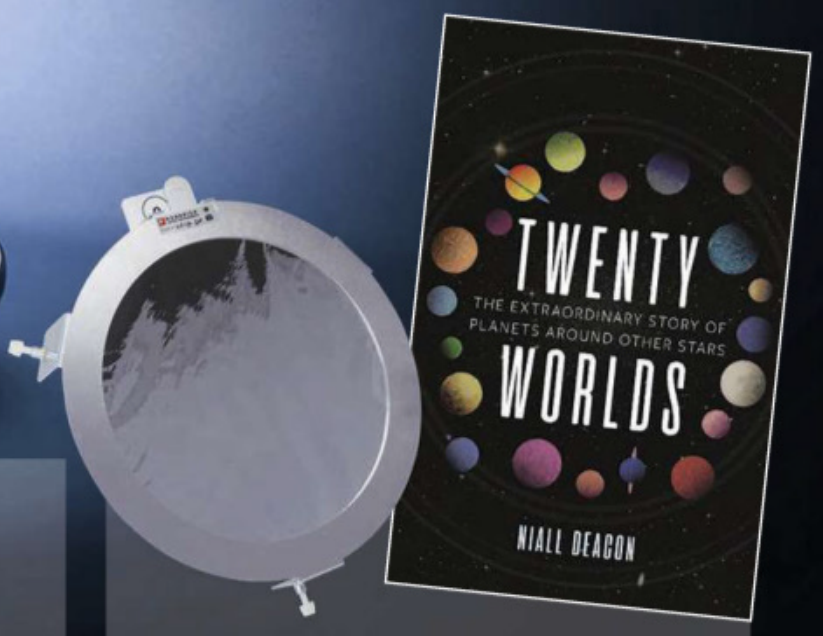

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

PLUS: Books on exoplanets, future space travel, neutron stars and more, and a look at the latest astronomy gear

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FIRST LIGHT

Sky-Watcher Heritage 150P Flextube Dobsonian

A simple to set up, portable scope that delivers a decent range of views

WORDS: PAUL MONEY

VITAL STATS

- **Price** £219
- **Optics** 150mm (6-inch) parabolic mirror
- **Focal length** 750mm (f/5)
- **Mount** Single-arm, wooden altazimuth Dobsonian mount
- **Focuser** Rack and pinion
- **Extras** red dot finder, 1.25-inch 10mm and 25mm eyepieces
- **Weight** 7.5kg
- **Supplier** Optical Vision Limited
- **Tel** 01359 244200
- **www.** opticalvision.co.uk

Since the introduction of the Heritage 76 in 2009, Sky-Watcher's tabletop Dobsonian telescopes have offered an affordable way for anyone to explore the wonders of the Universe. The Heritage 150P Flextube has now been added to the series, to deliver a greater light-gathering capacity than the previous largest in the range, the Heritage 130 – increasing it by 33 per cent.

The Heritage 150P comes preassembled in an attractive presentation box, with smaller boxes for the eyepieces and red dot finder. The latter needs a screwdriver to attach it to the telescope, but once that's done there's no need to take it off again. The Flextube design allows the front end of the telescope, to extend on two struts. Then, after use, the front end neatly slides back into the lower half of the tube, making it very compact and convenient to store.

The front end of the telescope houses the secondary mirror, a helical focuser and a place to attach the finderscope. There's also a dust cap to protect the scope's optics. Two eyepieces are provided, 25mm and 10mm, giving magnifications of 30x and 75x respectively. The red dot finder works well and has adjustable brightness, a useful feature which means it doesn't overpower the view at the lowest setting.

Adjusts with ease

The mount is a single-arm tabletop Dobsonian and is very easy to operate, with free movement on both the azimuth and altitude axis. The altitude axis is tensioned using a large knob, so you can balance the tube assembly and give enough free movement to adjust the tube with just your finger.

The tube is attached by a Vixen-style clamp and there's enough length on the mounting bar to achieve good balance. One minor niggle with is that you can't rotate the tube to position the focuser and eyepiece into a better position. Unless you use a low table, you may find you have to stretch over the telescope to reach the eyepiece.

We took a tour of the best summer Milky Way targets, beginning low down in the northeast with ▸

Lightweight and portable design

Sky-Watcher's range of Heritage telescopes are designed to be highly portable and uncomplicated to set up, ideally on a tabletop where they can be placed so the eyepiece is accessible. Being so quick and easy to use, you can be stargazing in minutes, without the setup hassles of a more complicated system such as an equatorial mount.

At just 7.5kg, the Heritage 150P Flextube is relatively lightweight, so it can be brought out quickly to catch those elusive gaps in the clouds, or whisked away easily to a dark-sky site. We put this to the test when Comet NEOWISE was at its best earlier this year, but wasn't viewable from our garden. Collapsed down, the Heritage 150P was easily transported in the car and then set up quickly in a dead-end road away from any streetlights. With it we were able to enjoy impressive views of the comet, making out the detail of the dust tail emerging from the coma. This goes to show that its compact design will appeal to anyone who wants a hassle-free get-up-and-go visual system.

@THESHED/PHOTOSTUDIO X 4, PAUL MONEY

Focuser

The focuser is a helical style and takes 1.25-inch fit eyepieces. There was some play when rotating in and out of focus, but generally it did the job intended. Two thumbscrews keep the eyepiece in place and are also useful when rotating for focus.

Finder

The supplied red dot finder is a suitable choice for this size of telescope as it's simple to use and lightweight so as to not overbalance the scope. The brightness of the red dot can be adjusted; we found the dimmest setting did not overpower the view and could still be seen.

Mount

The single-arm altaz mount provides 360° movement in azimuth, while the altitude axis movement is smooth and adjusted with a nice chunky knob at the side. The telescope is attached to the mount with a Vixen-style bar and can be adjusted easily for balance.

Eyepieces

Two basic eyepieces with rubber eyecups are supplied, a 25mm (with 30x magnification) and a 10mm for higher magnification (75x). They worked well for this focal system and gave pleasing views of a wide range of celestial targets. The setup could be enhanced further with a 2x Barlow lens.

FIRST LIGHT

A slightly cropped image of the Moon, taken with an iPhone XR and smartphone adaptor connected to the Sky–Watcher Heritage 150P and its 10mm eyepiece

KIT TO ADD

1. Sky-Watcher x2 deluxe Barlow lens (1.25-inch)

2. Sky-Watcher dual-LED night vision torch

3. Optical Vision Ltd 1.25-inch light pollution filter

▸ the Double Cluster in Perseus, using the 25mm eyepiece. It sparkled against the light sky and stood out well. The 10mm eyepiece allowed closer examination of each of the clusters, revealing several of the orange stars scattered throughout them. We picked out the clusters M34, M103 and, higher up, M52, before swinging over to view Albireo, the best double star the summer night sky has to offer. Although it was split well with the 25mm eyepiece, we found the colours showed more vivid sky blue and golden orange with the 10mm. Indeed, by using the 10mm we could split the famous Double Double star Epsilon Lyrae.

Nice nebulae

After viewing the hollow ring-like structure of the Ring Nebula, M57, in Lyra with the 10mm eyepiece, we moved down to the Dumbbell Nebula, M27, which was a lovely sight with a well-defined shape. We also spotted the Swan Nebula, M17, and viewed the hazy nature of the Sagittarius Star Cloud, M24, among a wealth of targets in this part of the sky.

Moving on to the planets, we found that Jupiter displayed its banded nature and all four Galilean moons were easily seen with the 25mm and 10mm eyepieces. Saturn's rings were obvious in the 25mm eyepiece, while there was a hint of the Cassini Division in moments of good seeing conditions with the 10mm. Its moons, Titan and Rhea, were also spotted to add to the fun. Meanwhile, the Moon provided lots of detail – the Heritage 150P will keep you happy exploring its surface details for many nights.

Although it's not a photographic instrument, we were able to image the Moon by connecting our smartphone, an iPhone XR, via our own adaptor, which was an added bonus.

Overall, this is a nice grab-and-go setup, a simple to use tabletop Dobsonian that can fire the imagination and provide decent views of a wide range of targets.

Optics

The 150mm (6-inch) parabolic mirror has a relatively short or 'fast' focal length of just 750mm, giving the system a focal ratio of f/5. Given its size, the optics performed well and provided a satisfactory range of views, from lunar and planetary, to brighter deep-sky targets and Comet NEOWISE.

VERDICT

Assembly	★★★★½
Build & Design	★★★★☆
Ease of use	★★★★½
Features	★★★★☆
Optics	★★★★☆
OVERALL	★★★★☆

TWO EYES FOR THE GALAXY

Our insider tips for binocular astronomers

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Photo: Cristian Fattinnanzi

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Article No. 61493

The night may be dark and clear, or the band of the Milky Way may glisten above you. But to turn observing into an unforgettable experience, you need one thing above all: binoculars with outstanding optics. Brightsky binoculars provide wonderful views thanks to a cleverly-constructed optical system. Because it's not just what you see, but how well you see it that matters.

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Magnesium body

A reliable companion on every tour: the body is made of magnesium, which makes it especially light, but also stable. The perfect basis for great journeys and experiences that are more exciting than a bus trip!

Single focusing

Astro-binoculars are meant for just one distance: the view into infinity. Therefore, the single adjustable focusing is extremely practical, because it cannot be accidentally readjusted. You just have to point your binoculars at the sky, enjoy the experience and not worry about anything else.

Nitrogen-filled

Moisture can't affect your binoculars: the nitrogen filling means that it is completely waterproof and protected against fogging. An ideal companion for all conditions and any location you visit. The rubber housing also makes it robust and shock-resistant. A really unique instrument for every outdoor assignment.

Interchangeable 18mm flat field eyepieces

Marvel at the large section of the sky. With the 18mm flat field eyepieces, you can see more of the starry sky compared to other binoculars. Large ocular lenses invite you to observe in comfort, with or without spectacles. With a 65° field of view and a particularly flat field, you enjoy sharp images right up to the edge. That's unusual for binoculars: The interchangeable 1.25" eyepieces offer you a standard filter thread to use filters to highlight faint details in nebulae. That way you can see what remains hidden to others.

90° viewing angle: perfect for amateur astronomers

A comfortable viewing position is just as important for observing as good mechanics. Eyepieces with a 90° view are particularly suitable for those who like to observe objects close to the zenith. The 45° models offer a comfortable view of the horizon. It's a fact: if you observe comfortably, you can see further!

Brightsky	Article No.		Price in £
Large binoculars 22x70	**45°**	**90°**	
WxHxD in mm 390x215x185, weight 3.9kg (8.6lbs)	61488	61489	**1,000.00**
Large binoculars 26x82	**45°**	**90°**	
WxHxD in mm 450x220x190, weight 4.6kg (10.1lbs)	61490	61491	**1,140.00**
Large binoculars 30x100	**45°**	**90°**	
WxHxD in mm 510x265x200, weight 6.8kg (15.0lbs)	61492	61493	**1,270.00**

FIRST LIGHT

Bresser Spezial
Astro SF 15x70 binoculars

No-nonsense bright binoculars that are ideal for a variety of astro observations

WORDS: STEVE TONKIN

VITAL STATS

- **Price** £269
- **Optics** Fully multi-coated
- **Aperture** 70mm
- **Magnification** 15x
- **Prisms** Porro, BaK-4
- **Angular field of view** 4.4°
- **Focusing** Individual eyepiece
- **Eye relief** 20mm
- **Interpupillary distance** 56–74mm
- **Weight** 1.9kg
- **Supplier** Bresser UK
- **Warranty** 5 years
- **Tel** 01342 837098
- **www.**bresseruk.com

ALL PICTURES: @THESHED/PHOTOSTUDIO

A pair of 15x70 binoculars occupies a useful astronomical niche. When they are mounted they show substantially more detail and depth than smaller handheld binoculars, but they can also, if necessary, be handheld for short periods as well. Naturally, as the Bresser Spezial Astro SF 15x70 binoculars are a new entrant to that niche, they grabbed our attention.

The Spezial Astro SF 15x70s come in a rugged woven nylon case, with a padded neoprene neck strap, tethered objective lens caps, attachable rain guard-type eyepiece covers, microfibre cleaning cloth and an instruction leaflet. The aluminium body is covered with a ribbed rubber armour and has a converter bush for a tripod adaptor (not included) at the objective end of the hinge. The hinge moves smoothly, with enough resistance to prevent it from sagging when the binoculars are mounted, but not so much as to make it difficult to adjust. The individual eyepiece focusers are also smooth, but less stiff than the hinge, so you can focus the mounted binoculars without affecting the interpupillary distance (the distance between the pupils of your eyes). The eyepieces can be folded down if you observe with spectacles, and you can see the entire field of view without pushing your glasses against the eyepieces.

Using a bright torch to examine the inside of the binoculars, we noted that the prisms are secured in proper cages and that the insides of the objective tubes are ribbed in order to reduce stray light and combat spurious reflections.

Moon and stars test

We tested the Spezial Astro SF 15x70s under good suburban skies, mounted on either a parallelogram mount or a monopod and trigger-grip, in addition to a few brief handheld excursions. We found it easy to obtain a precise focus on our first target, a first quarter Moon. With either the terminator or the limb in the middle of the field of view, false colour was barely perceptible, and it was only at the periphery ▸

Bright optics

Since the invention of the telescope, the cry of astronomers has been, "More light!" – you want as much as possible of the light gathered by the objective lenses to be transmitted to your eyes. The Spezial Astro SF 15x70s meet this requirement: there is none of the stopping down of the light cone that some binoculars use to reduce aberrations and sharpen the image, although there was a minuscule obstruction from a component in the prism cages. This in turn requires that optical aberrations are well controlled. Except at the very edge, you will experience a flat field of view, with sharply focused stars and very little false colour. Finally, where the light meets a glass surface, reflection must be minimised, something achieved with anti-reflective coatings. Shining a torch into the lenses suggests that their glass–air surfaces all meet the "fully multi-coated" specification. This is a reassuringly bright pair of binoculars.

Individual focusing

Individual eyepiece focusing is the preferred option for astronomical binoculars, where the convenience of centre-focus is not required. Not only does it enable precise focus for each eye to be set and left alone, but the lack of a moving eyepiece bridge makes effective waterproofing easier to maintain.

Waterproof and argon filled

Observing in dewy conditions brings the risk that humid air will condense inside the binoculars, eventually leading to oxidation of metal parts and damaging algal or fungal growth. As the Spezial Astro SF 15x70s are waterproofed and filled with inert argon, this source of potential damage is effectively eliminated.

Tethered lens caps

Not only will you not lose or drop the tethered lens caps, but they are also instantly deployable to prevent dewing of your lenses if you take a break from observing. These lens caps fit extremely well and, unlike some, the rainguard-type eyepiece covers do not limit the interpupillary distance.

FIRST LIGHT

Aluminium body

Rubber armour covers an aluminium body, in which the prism housing is built into the objective tubes. It has a comfortingly robust feel, due to the weight. If handheld, this may become tiring, but it will also dampen any shakes if you use the binoculars to briefly scan the sky.

Good IPD range

With an IPD (interpupillary distance – the distance between the pupils of the eyes) ranging from 56mm to 74mm, these binoculars will suit a variety of faces. At the minimum of 56mm there is only 10mm between the chunky eyepieces, but the pliant rubber eye-cups will comfortably fit the bridge of your nose.

KIT TO ADD

1. Bresser BX-5 tripod

2. Bresser flexible gooseneck smartphone holder

3. Bresser tripod adaptor for binoculars

▸ that it became obtrusive. We did notice, however, that when the Moon was within about 10° of the target area, there was sufficient stray light to degrade the image.

Away from the Moon, we found there to be good image contrast and colour rendition. Albireo was conveniently placed and we found that its two components stars – one bright gold, the other dimmer blue – showed good colour contrast and were cleanly split almost to the edge of the field of view. Despite its low elevation, we were able to detect the crescent of a rising Venus, and Jupiter's glare at opposition was controlled well enough to enable us to see the Galilean moons close to the planet.

Deep-sky delights

Where the Spezial Astro SF 15x70s really come into their own, however, is with deep-sky objects. You would expect the Andromeda Galaxy, M31, to be bright, and so it was. The companion galaxies, M32 and M110, were obvious, as was the more abrupt light cut-off due to the dust lane on the nearer edge. The much fainter galaxies that we tried, M33, M51 and M101, were all easily identified, even when the binoculars were handheld. The North America Nebula, NGC 7000, required them to be mounted, when it too became obvious.

Testing the binoculars during the short summer nights meant that we had access to views of the southern Milky Way. A particular delight was being able to directly compare the large clusters IC 4756 and NGC 6633 in the same field of view. Even the Ptolemy Cluster, M7, was visible as it skirted the southern horizon. These successes tempted us to go on a dark nebula hunt in the constellation of Aquila. This too was fruitful: the 'C' part of Barnard's E dark nebula, B142, was particularly easy to make out, which also revealed the sinuous curve of Barnard's Black Lizard, B138, as it wove its way south from 23 Aquilae.

The manufacturer has obviously responded to observers' calls for a no-nonsense pair of binoculars with useful features. The Spezial Astro SF 15x70s will appeal to both the binocular observers and those with more experience who wish to step up from budget models.

VERDICT

Build & design	★★★★½
Ease of use	★★★★½
Features	★★★★½
Field of view	★★★★☆
Optics	★★★★☆
OVERALL	★★★★½

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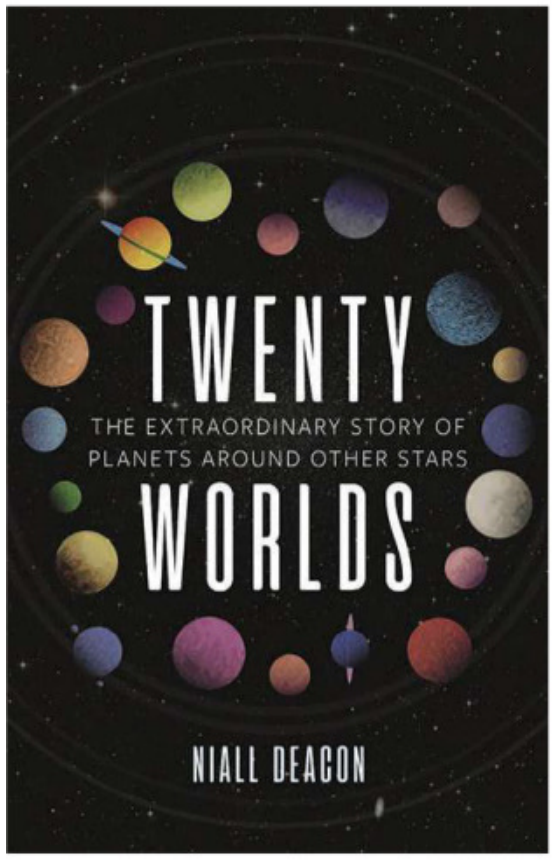


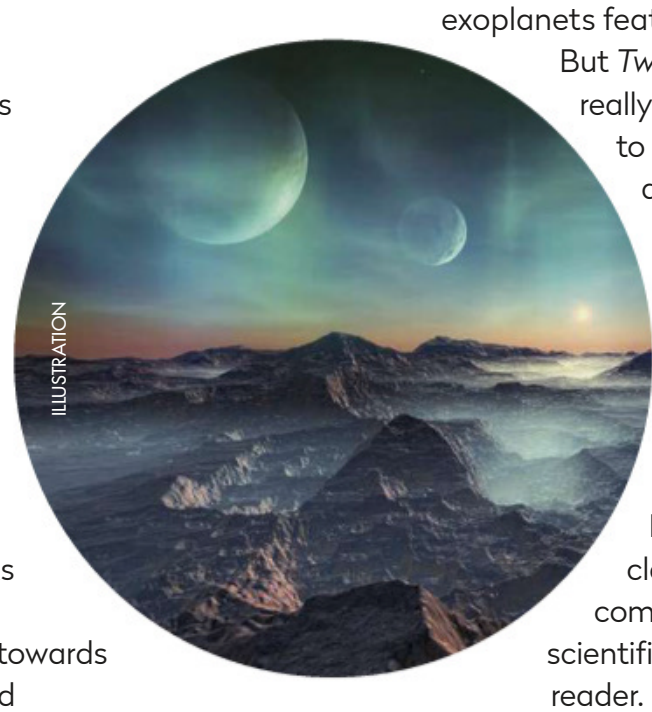
Twenty Worlds

Niall Deacon
Reaktion Books
£15.95 ● HB

Twenty Worlds takes a look at the ways we have discovered exoplanets, planets beyond our Solar System, framing the narrative around 20 alien and extraordinary worlds found in orbit around distant stars. Deacon breaks them down into five categories – 'alien', 'towards Earth', 'birth', 'life' and 'death' – and then uses these to detail not only the exoplanets themselves, but how they relate to us.

Aimed at an audience with no prior knowledge of exoplanets, *Twenty Worlds* paints a picture of each method used by science today to find and measure alien worlds. Each is framed around a real exoplanet and aims to explain "just how do we know the things we know?" For any young astronomers (GCSE through to undergraduate), this is the perfect book to introduce exoplanet science. It is also the ideal book for teachers to pick apart these techniques with fascinating examples. For example: have you ever thought about why stars are drawn as being spikey when we know they are round balls, or dots in the sky? The author uses this and the way our eye – an optical system – converts and transmits light, to explain how we can get a direct image of an exoplanet orbiting around another star, using the most advanced adaptive optic systems on the world's largest telescopes.

While the book is called *Twenty Worlds*, the planets themselves are token examples of a particular discovery method or technique. You only get the smallest tantalising glimpse of what amazing science and discoveries these worlds have to offer, and the book barely touches the surface of the latest exciting information we have on the specific exoplanets featured.



ILLUSTRATION

▲ **Niall Deacon takes a tour of weird worlds to explain how we know what we know**

RASTAN/ISTOCK/GETTY IMAGES

But *Twenty Worlds* is not really for those who want to find out more about any one of the planets covered; rather it reveals what each of them represents to the field in general. Its real value is in the analogies that Deacon uses to clarify difficult and complex exoplanetary scientific methods to the reader. Nowhere will you find a more descriptive book to understand the processes used to learn about the existence of these worlds.

★★★★★

***Dr Hannah Wakeford** is an astrophysicist at the University of Bristol, where she studies exoplanets using the Hubble Space Telescope*

Interview with the author
Niall Deacon

Why is exoplanet science such a big topic right now?

The study of galaxies outside the Milky Way only got going in earnest 100 years ago. This October is the 25th anniversary of the first exoplanet being found around a star similar to the Sun. This opened a whole cornucopia of weird and wonderful worlds to explore and for our imaginations to run riot with.

What can exoplanets teach us about our own Solar System?

The Solar System is a snapshot in time: eight middle-aged worlds around one star. By studying exoplanets, we have access to a time machine to look at the still-forming worlds around young stars and learn how our own Solar System formed. We can also see the far future of our Solar System in the planetary systems around stellar remnants like white dwarfs.

What are the most mind-blowing exoplanets?

For me it's the three planets orbiting the pulsar PSR B1257+12, likely the result of a neutron star ripping its white dwarf companion to shreds, with the planets forming from the debris. Then there's WASP-12b, a gas giant so close to its parent star that the intense stellar radiation has caused it to swell up so much that it's falling apart.

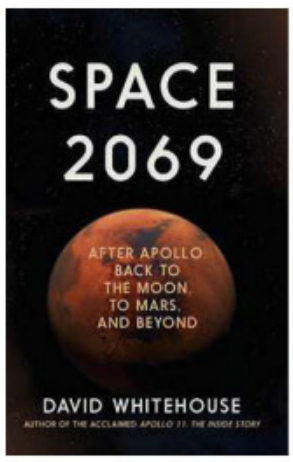
Could probes be sent to study exoplanets?

There's been a proposal to send a swarm of probes to Proxima Centauri b. It would take at least a generation to get there, and a huge amount of money and technological progress. I think we'd benefit more from putting all that effort into projects based on more conventional observing techniques.

***Niall Deacon** is an astronomy researcher focused on studying brown dwarfs and exoplanets*

Space 2069

David Whitehouse
Icon Books
£16.99 ● HB



It is rare to read something that so closely mixes science fiction with reality, but *Space 2069* does just that. From the pen of former BBC science correspondent David Whitehouse, whose previous works include *Apollo 11: The Inside Story* and *The Moon: A Biography,* this book may be small in stature, but it packs a sizeable punch. It affords us an intelligent portrait of where we may be in the next half-century: from an Antarctica-like set-up of international Moon bases to outposts on the Red Planet.

Whitehouse's simple style draws on his own childhood aspirations and it is not hard to discern simmering frustrations as he ponders our lack of progress since 1969. "Changes have been made faster in some areas," he laments, "slower in many others." Had he been asked after Armstrong and Aldrin's initial lunar steps where we might be in 2019, he would have expected us to be exploring deep space. Sadly, this did not come to pass.

As such, his outline of 2069 – centenary events from 'First Footprint Sanctuary' at Tranquility Base, and colonies on Mars whose residents have never walked the Earth – is resoundingly optimistic, but still tainted by a dark thread of gloom. Whitehouse is too conscious of where the last 50 years have *not* taken us to be under any rose-tinted illusions. Exploring the outer planets, for example, is still beyond even the 2069 generation.

However, after reading this book you will be left with a glimpse of a future which is far from utopian, but certainly offers a sense of realism for what the next 50 years might hold. ★★★★☆

***Ben Evans** is the author of several books on human spaceflight and is a science and astronomy writer*

Neutron Stars: The Quest to Understand the Zombies of the Cosmos

Katia Moskvitch
Harvard UP
£23.95 ● HB

Neutron stars are some of the densest, most rapidly spinning objects in the Universe, and the focus of this fantastic new title. Moskvitch says it best, that the reader will "travel beyond the observatories, through space and time, to the outskirts of our Galaxy and farther, into the intergalactic vastness".

From the great Interplanetary Scintillation Array (ISA) that listened to the first pulsar, to the half-pipe-shaped Canadian Hydrogen Intensity Mapping Experiment (CHIME) searching for repeating radio signals, *Neutron Stars* features instruments old and new. Not only are there great insights into the physics that underpin these zombie stars, but they are often explained using anecdotes from scientists all over the globe. Particular highlights are the 'Deeper Dives', brief interludes that take a closer look at some of the topics touched on in the main narrative – fascinating questions such as the origin of gold and 'why was the kilonova blue?' looking at how elements form in space and why hotter cosmic objects are blue, rather than red.

SUPERB STELLAR SCIENCE

My favourite part is the final section, 'Fast Radio Bursts, the unfinished chapter', reflecting on how there is so much left to learn. This cleverly reveals the reality of science and our desire to push forward our frontiers of understanding.

Moskvitch has written a beautiful book of personal stories, entwined with an exploration of these exotic stellar objects. It's the perfect accompaniment to cloudy, telescope-free evenings. ★★★★★

***Amber Hornsby** is a postgraduate researcher at Cardiff University*

Everything You Ever Wanted to Know about the Universe

Andrew Newsam
Elliot & Thompson Ltd
£11.99 ● PB

It's a bold assertion indeed to claim any book could contain everything you ever wanted to know about the Universe. Nevertheless, this new title makes a valiant attempt at a compendious survey of the cosmos.

The author presents an informative introduction to modern astronomical knowledge in just six chapters: a whistle-stop history tour, the Sun, the Solar System, stars, galaxies and the Big Bang. After the first chapter, the historical perspective is rightly dropped, except for an occasional box-out concerning historically important astronomers. Most readers, even younger ones, will have little trouble following the evidence, arguments and facts. Scientific terms and principles are adequately explained with patience and easy-to-follow language. The most useful discussions for the uninitiated reader are on topics such as Big Bang cosmology, dark matter and dark energy, all succinctly explained.

However, amateur enthusiasts could be left wanting something more. The range of subject material feels meagre, the level of detail cursory and the assumption of ignorance too absolute. This could leave the more seasoned science buff somewhat disappointed. While being consistent and fluid as a whole, the writing isn't as inspiring as one would expect from a modern popular science book. Because there is so much to cover in so few paragraphs there is a lack of strong analogy and little poetry to the writing style.

For the absolute beginner, though, this quick and easy survey is unpatronising, direct and comprehensible. It just might not be what the cover purports it to be for all. ★★★☆☆

***Alastair Gunn** is a radio astronomer at Jodrell Bank Observatory in Cheshire*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Baader flip mirror II

Price £175 • **Supplier** DHinds
Tel 01525 852696 • **www.dhinds.co.uk**

ADVANCED The constant switching between an eyepiece and camera can use up valuable imaging time, but this flip mirror reduces that delay to the turn of a knob. It has a third port to attach an autoguider and make your setup more versatile.

2 Kendrick solar filters

Price from £62 • **Supplier** Widescreen Centre
Tel 01353 776199 • **www.widescreen-centre.co.uk**

When you're solar observing, it's sometimes difficult to centre the Sun in your eyepiece, but this filter's built-in finder makes it a doddle. The filter is made from Baader AstroSolar film to ensure safe solar viewing and is available in a range of sizes.

3 Stars pinhole constellation cards

Price from £14.99 • **Supplier** Books etc
Tel 01353 776199 • **www.booksetc.co.uk**

Knowing the constellations is vital for astronomers navigating around the night sky. These pin-hole cards, featuring 20 of the best constellations, will help you learn their shapes, while the accompanying book teaches you their mythology and history.

4 Explore Scientific M48 Extension Tube Set

Price from £44 • **Supplier** Harrison Telescope
Tel 01322 403407 • **www.harrisontelescopes.co.uk**

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5 Planets in Time

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https://planetsintime.com/

Every day is unique, so why not commemorate those most special to you with a custom print that captures the position of the planets on any given date? Planets in Time uses NASA data to work out the orbits, before creating a 50cm x 50cm print on high-quality art paper.

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Ezzy Pearson interviews Matija Cuk

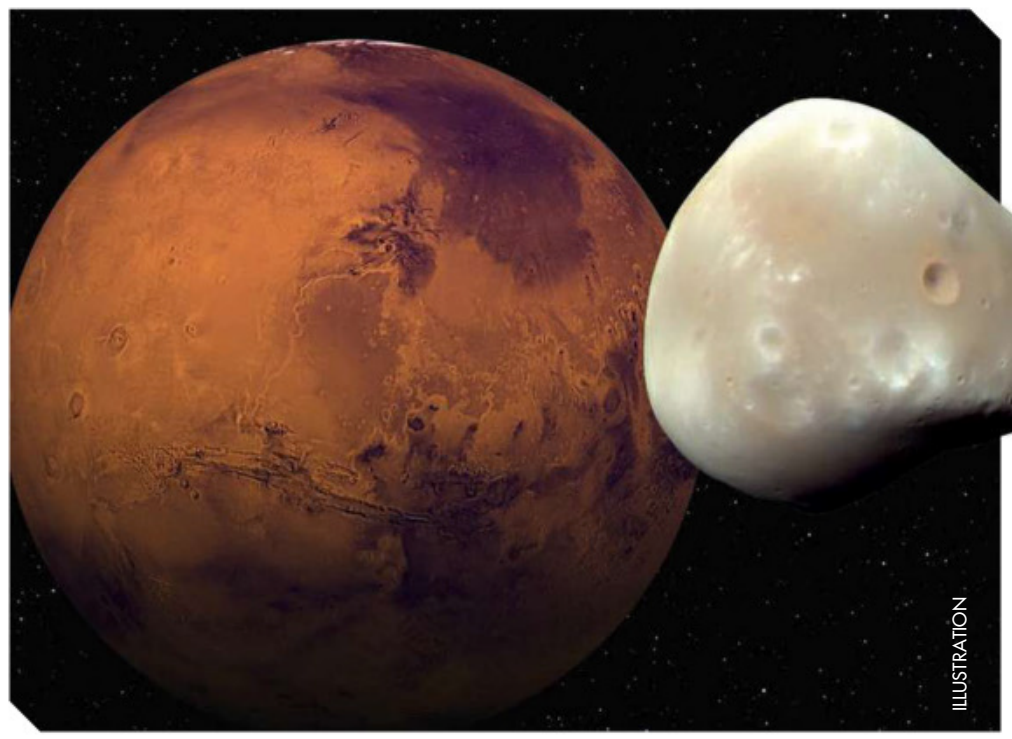
Q&A WITH A MARS MOON SCIENTIST

Could the unusual gravitational tilt of Mars's moon Deimos be the relic of an ancient grandparent, long since destroyed?

What's so unusual about the orbit of Mars's moon Deimos?
Both Phobos and Deimos are orbiting close to the equatorial plane of Mars; most satellites of Jupiter and Saturn do that and it's a strong indicator that the moons formed together with the planet. What's really interesting though is that Deimos's orbit is not exactly in the equatorial plane but a bit off, by about two degrees. That doesn't sound much, but for orbital scientists it's a significant amount, so we have to figure out a way to see why it's tilted so much.

Is there anything else unusual about this moon's orbit?
The tilt of the orbit is only half the story because its shape is also atypical. All orbits are elliptical, but some are more elliptical than others; we measure the eccentricity of the orbit to tell us how non-round it is. Usually, eccentricity and inclination grow together – for example, if you get random kicks to the orbit by an impact or similar events then the tilt and eccentricity will grow together. But for Deimos's orbit it's not like that; the eccentricity is small yet the inclination is decisive, which indicates that one large process changed its inclination. We've been looking at what could have done that and we've realised that an orbital resonance with another moon could have been the cause, the orbital period of this other moon being related to Deimos's by a precise ratio.

Which moon might it have been in resonance with?
Mars does have another moon, Phobos, but it's too small to do this. However, a paper from a few years ago suggests that Phobos could just be a remnant of a moon-ring cycle at Mars. The theory is that Mars used to have bigger moons – the grandparents of Phobos – but each one fell down onto the planet, breaking up into rings, with each ring then forming a new moon. While some of the particles in the ring fall onto the planet, some of the material moves out and forms a new moon, with each successive moon being less massive than the previous one. This indicates that Deimos's tilt was caused by the grandparent of Phobos.



ILLUSTRATION

▲ Deimos's unusual tilt gives clues about the size of its grandparent moon

Does this mean that Phobos will also break apart one day?
The problem with a moon being as close to its planet as Phobos is to Mars, is that it's orbiting faster than the planet is spinning. That means the gravitational tides are pushing Phobos in the opposite direction from other planetary satellites. In most systems, the moon moves away from the planet due to the tides, but Phobos's rapid orbit is decaying and falling into Mars. Any previous moon in the same position would have done the same. Phobos is supposed to crash into Mars in about 40 million years, but it won't make it to the surface. It will get close and then the gravity of Mars will pull it apart and the debris will form a ring.

How does this ring-moon cycle effect Deimos?
For the orbital resonance to tilt Deimos, you need the two moons – an inner one and Deimos – to have converging orbits, and their distance also has to be decreasing. Since Deimos doesn't move much, the inner moon has to move out ,which is opposite to the effect of Mars's tides alone. There has to be something other than Martian tides causing it to move out and that's where the ring comes in. When you have a moon and ring together, the moon is always exterior to the ring, and so the ring is pushing it out. It's a very specific thing you can't get around; if the inner moon is going to move out, then there also has to be a ring there at that time.

At what point does Phobos's grandparent moon cause the tilt of Deimos?
As the inner moon, the grandparent of Phobos, moves out, at some point its orbital period will be exactly one third that of Deimos. As it moves out it will pick up Deimos, which stays at a 3:1 ratio with the inner moon. As Deimos is pushed out, its tilt continues to increase. The tilt at the point when the pairing breaks up will tell us what the mass of the inner moon was. Simulations tell us that was about 20 times that of Phobos.

Matija Cuk is a research scientist with the SETI Institute researching Solar System dynamics

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Explore the surface features of Mars while it's at opposition and enjoy a pair of edge-on spiral galaxies

When to use this chart

1 Oct at 24:00 AEST (14:00 UT)
15 Oct at 23:00 AEDT (12:00 UT)
31 Oct at 22:00 AEDT (11:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

OCTOBER HIGHLIGHTS

October belongs to Mars. Most of the time its small angular size (averaging around 10 acrseconds) makes it tricky for us to glimpse surface features like mountain ranges, volcanos, valleys and plains, but this month we'll see the Red Planet at opposition and at closest approach reaching 22.4 arcseconds in the eyepiece – its most favourable apparition until 2033. Mars is fascinating to observe, presenting a different nightly view and with dust storms altering its appearance.

STARS AND CONSTELLATIONS

The constellation of Grus the Crane has two prominent stars, Alpha (Alnair) and Beta (Alphaulka) Gruis. From the Northern Hemisphere this bird can be visualised as walking along the southern horizon. Although the stars mark the position of its feet, these common names relate to when Grus was part of Piscis Austrinus's fish. The cool M-type red giant star Beta Grui presents quite a colour contrast to nearby Alpha, which is a hot B-type bluish-white star.

THE PLANETS

Mars dominates the early eastern evening sky and is visible all night; it's at maximum brightness and now rivals that of Jupiter, which along with Saturn, resides in the northern evening sky. While Mercury's evening sky return ends as it dives back into the Sun's glare late in October, Neptune is well placed for observing as its due north at 22:00 mid-month, with its fellow outer Solar System companion, Uranus, following three hours later. Meanwhile, Venus continues to dominate the predawn eastern sky.

DEEP-SKY OBJECTS

Take a ride on Pegasus this month, as Eta Pegasi (RA 22h 43.0m, dec. +30° 13') is easily visible to the unaided eye. A small scope shows a colourful wide double star with a bright (mag. +2.9) yellow primary and a distant (99" away) faint mag. +9.9 blue companion.

Next, we visit two edge-on spiral galaxies. NGC 7332 (RA 22h 37.4m, dec. +23° 48') is easily found between two isolated (7th magnitude) stars, 0.5° apart. At mag. +11.1 the galaxy has a bright star-like nucleus with an elongated core, surrounded by a fainter, but elliptical halo (around 2' x 0.5') orientated almost north to south. Easily fitting in the same eyepiece view is NGC 7339, only 0.1° east. This has a similar shaped halo, but is fainter without noticeable brightening at the centre. NGC 7339's east to west orientation makes it point towards 7332.

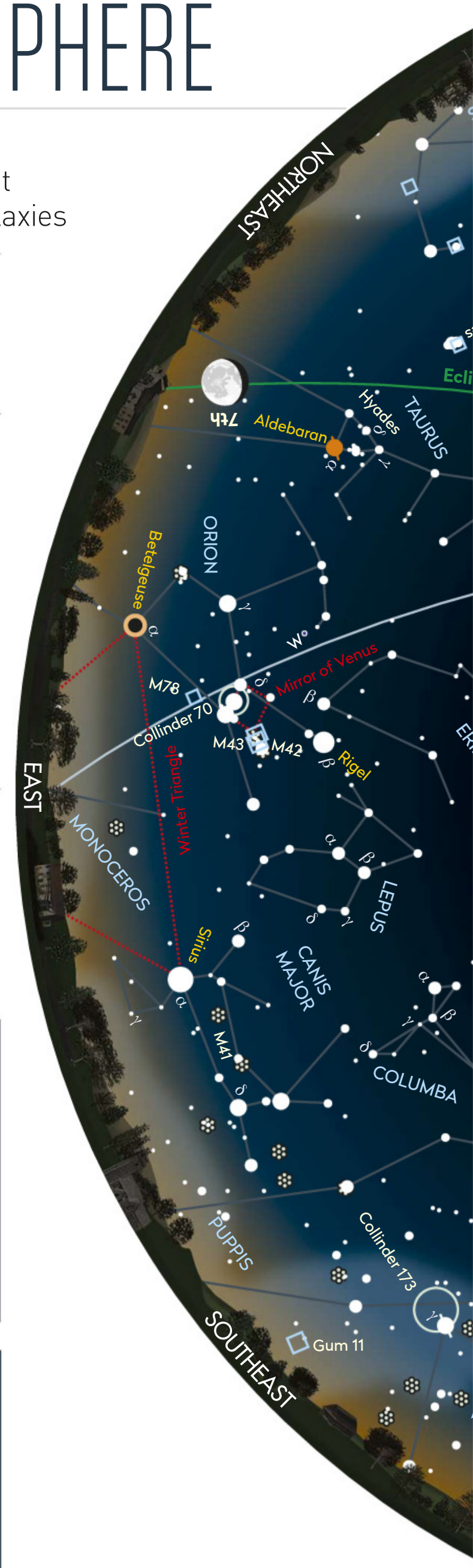
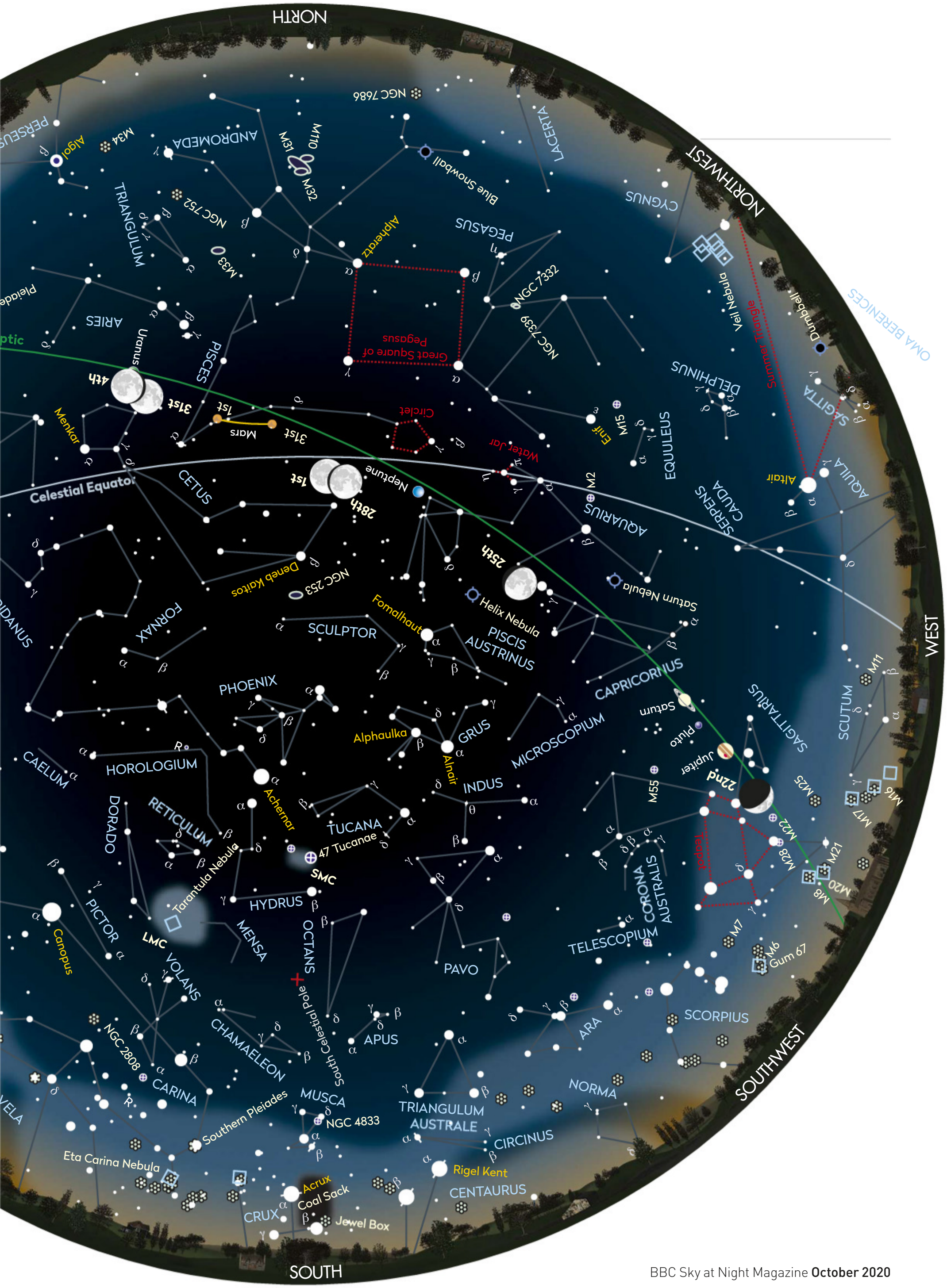


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
NGC 7686
Blue Snowball
M31
M110
M32
ANDROMEDA
M34
Algol
PERSEUS
LACERTA
CYGNUS
Veil Nebula
Dumbbell
Summer Triangle
OMA BERENICES
NGC 752
TRIANGULUM
M33
Alpheratz
PEGASUS
NGC 7332
NGC 7339
Great Square of Pegasus
ARIES
Pleiades
Uranus
PISCES
Circlet
Mars
1st
31st
4th
Menkar
Celestial Equator
Water Jar
Enif
M15
EQUULEUS
DELPHINUS
SAGITTA
AQUILA
Altair
SERPENS CAUDA
Neptune
28th
1st
CETUS
M2
AQUARIUS
25th
Saturn Nebula
Helix Nebula
Denab Kaitos
NGC 253
Fomalhaut
SCULPTOR
FORNAX
PISCIS AUSTRINUS
PHOENIX
Alphaulka
GRUS
Alnair
MICROSCOPIUM
CAPRICORNUS
SAGITTARIUS
SCUTUM
Saturn
Pluto
Jupiter
22nd
M55
M25
M16
M17
M11
CAELUM
HOROLOGIUM
Achernar
INDUS
DORADO
RETICULUM
TUCANA
47 Tucanae
Tarantula Nebula
SMC
Teapot
M22
M28
M21
M20
M8
CORONA AUSTRALIS
HYDRUS
PICTOR
Canopus
LMC
MENSA
OCTANS
South Celestial pole
PAVO
TELESCOPIUM
M7
M6
Gum 67
VOLANS
CHAMAELEON
APUS
ARA
SCORPIUS
NGC 2808
CARINA
Southern Pleiades
MUSCA
NGC 4833
TRIANGULUM AUSTRALE
CIRCINUS
NORMA
Eta Carina Nebula
Acrux
Coal Sack
Jewel Box
CRUX
Rigel Kent
CENTAURUS